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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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VOL. CVIII.—No. 2808.] *LONDON: FRIDAY, OCTOBER 24, 1919.* [*Registered at the General Post Office as a Newspaper.*] [PRICE 9d. BY INLAND POST ... 11d.]

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STEAM WAGONS. TRACTORS.
CEMENT-MAKING MACHINERY. 7667

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BOILER FEED PUMPS.
See Advertisement, page 33.
PATENT WATER-TUBE BOILERS,
AUTOMATIC FEED REGULATORS,
And Auxiliary Machinery as supplied to the Admiralty. 2179

Henry Butcher & Co.,
VALUERS AND AUCTIONEERS
to the
ENGINEERING AND ALLIED TRADES.
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PLANT AND MACHINERY. 6391
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HYDRAULIC and HAND.
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GEORGE RUSSELL & CO., LTD.,
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Thos. Piggott & Co., Limited,
BIRMINGHAM. 7410
See Advertisement last week, page 136.

Plenty and Son,
LIMITED.
MARINE ENGINEERS, &c.
NEWBURY, ENGLAND. 9083

Tank Locomotives.
Specification and Workmanship equal to Main Line Locomotives.
R. & W. HAWTHORN, LESLIE & CO., LTD., ENGINEERS, NEWCASTLE-ON-TYNE. 7260

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State price and where can be seen.—BOX T.R., SMITH'S Advertising Agency, Ltd., 100, Fleet Street, London, E.C. 4. A 670

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See page 16. 7454

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BUTTERWORTH BROS., Ltd.,
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Electric Transporters.
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SPECIALISTS
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SALE AND VALUATION
of
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and
ENGINEERING WORKS.
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Tubes and Fittings.
6920
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See Advertisement page 109, Oct. 17.

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SHIPBUILDERS AND ENGINEERS,
GLASGOW.
SPEEDS UP TO 45 MILES AN HOUR.
PADDLE OR SCREW STEAMERS OF EXCEPTIONAL SHALLOW DRAUGHT.
Repairs on Pacific Coast
by YARROWS, LIMITED, Victoria, British Columbia. 7769
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Worm Wheels cut up to 13 ft. diam.
Bevel and Mitre Wheels planed up to 3 ft. diam.
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Yachts, Launches, or Barges,
Built complete with Steam, Oil or Petrol Motors; or Machinery supplied. Od 3551
VOSPER & CO., LTD., BROAD STREET, PORTSMOUTH.

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Drop Forgings
write
GARTSHERRIE ENGINEERING & FORGE CO., 50, Wellington Street, Glasgow. 7598

Oil Fuel Appliances.
SYSTEMS { PRESSURE, AIR, STEAM.
FOR BOILERS OF ALL TYPES.
Kermodes Limited,
35, THE TEMPLE, DALE STREET, LIVERPOOL;
and
109, FENCHURCH STREET, LONDON. 4078
NAVAL OUTFITS A SPECIALTY.

Locomotives Tank Engines
designed and constructed by
MANNING, WARDLE AND COMPANY, LIMITED, Boyne Engine Works, Leeds Od 2487
See their Illus. Advertisement, page 147, last week.

Cochran MULTITUBULAR AND CROSS-TUBE TYPES.
Boilers,
See page 17. 7263

RAILWAY AND TRAMWAY ROLLING STOCK.
Hurst, Nelson & Co., Ltd.
THE GLASGOW ROLLING STOCK AND PLANT WORKS, MOTHERWELL. Od 3383

Synonyms:—
"Aptol" Oils
AND 7184
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Henry Wells Oil Co.,
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(UP TO 35 TONS.) 7183
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GOVAN, GLASGOW. LTD.
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MANUFACTURERS OF
RAILWAY CARRIAGE, WAGON & TRAMWAY WHEELS & AXLES.
CARRIAGE & WAGON IRONWORKS, also CAST-STEEL AXLE BOXES. 7312

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MANUFACTURERS OF
RAILWAY CARRIAGES AND WAGONS
OF EVERY DESCRIPTION.
RAILWAY IRONWORK, BRIDGES, ROOFING, &c.
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MILLWALL, LONDON, E. 1316
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Tubes and Fittings.
Stewarts and Lloyds, Ltd.,
Glasgow and Birmingham.
See Advertisement page 20. 7268

CO_2 Plants (CARBON-DI-OXIDE)
for Chemical Wks., Mineral Water Mfrs., Breweries, and all other purposes. — AERATORS LTD., 109, Victoria St., S.W. 1 ("Pranspark, London.").

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are foremost as fire fighters. No Acids. No Alkalis. Safe to use and always ready.—BRITISH FIRE APPLIANCES Co., Ltd., 109, Victoria St., London, S.W. 1.
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Makers of
Evaporating and Distilling Plants.
Refrigerating and Ice Making Machinery.
Feed Water Heaters.
Feed Water Filters.
Evaporators.
Fresh Water Distillers.
Main Feed Pumps.
Combined Circulating and Air Pumps.
Auxiliary Surface Condensers.
&c., &c. 7736

Cement.—Maxted & Knott,
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Destroyers, Torpedo Boats, Yachts and Fast Boats, Submarine and Submersible Boats.
NORMAND'S Patent Water-tube Boilers, Coal or Oil Heating. Diesel Oil Engines.

Rubber MANUFACTURERS
Hose Steam and Air Drill
GUTTA PERCHA & RUBBER, LIMITED,
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Electric Cranes.
7182
S. H. HEYWOOD & CO., LTD.,
REDDISH.

R. Y. Pickering & Co., Ltd.,
(ESTABLISHED 1864.)
BUILDERS of RAILWAY CARRIAGES & WAGONS.
MAKERS of WHEELS and AXLES of all kinds.
RAILWAY WAGONS FOR HIRE.
Chief Works and Offices:
WISHAW, near GLASGOW.
London Office: 6353
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500 Kw. Generator, 440/500
volts, or 220/250 volts, d.c., 330 r.p.m., compound, interpoles; suitable for three wire system.
DIESEL ENGINES suitable for driving the above.
Similar (Two) GENERATORS for 250 Kw., 220/250 volts, 330 r.p.m., d.c.
MOTORS, Several 5/15 HP., 220/250 volts, d.c., compound, enclosed.
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West Walls, Newcastle-on-Tyne. 7069

Royles Limited,
ENGINEERS, IRLAM, MANCHESTER.
FEED WATER HEATERS,
CALORIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS, STEAM AND GAS KETTLES. } Row's Patents
Merrill's Patent TWIN STRAINERS for Pump Suctions.
SYPHONIA STEAM TRAPS, REDUCING VALVES
High-class GUNMETAL STEAM FITTINGS.
WATER SOFTENING and FILTERING. 5729

Yarrow Patent Water-tube Boilers.
7768
Messrs. YARROW & CO. UNDERTAKE the PRESSING and MACHINING of the various parts of Yarrow Boilers, such as the Steam Drums, Water Pockets, and Superheaters for British and Foreign Firms not having the necessary facilities.
YARROW & CO., LTD., SCOTSTOUN, GLASGOW.

Matthew Paul & Co., Ltd.
LEVENFORD WORKS, **Dumbarton.** 7660
See Full Page Advt., page 83, Oct. 17.

Forgings.
Walter Somers & Co., Ltd.,
HALESOWEN. 7715

"Delta" Brand HIGH-CLASS ENGINEERING ALLOYS.
Forgings, Castings, Bars, Sheets, Wire, Tubes.
THE DELTA METAL CO., LTD., 7169
E. GREENWICH, LONDON, S.E. 10 (& at Birmingham)

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8196
TAYLOR & CHALLEN, LD., Engineers, BIRMINGHAM
See Full Page Advertisement, Oct. 17.

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T. SUMMERSON & SONS, LIMITED,
DARLINGTON. 7903

AUTOMATIC ANALYSIS OF FLUE GASES.
Hays CO_2 Recorders,
Draught Gauges, Gas Analysers, Gas Collectors
Tested out on the High Seas in Naval Ships. 7854
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25, Victoria Street, Westminster, London, S.W. 1.
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Machine and Engineering
WORK of all description undertaken for Manufacturers, Patentees, &c. Also repairs and renewals. Best work, moderate charges.—ROSSER & RUSSELL, LTD., Queen's Wharf, Hammersmith.
NEW PATENT AUT.—ROSSER & RUSSELL, Ltd., are prepared to undertake the manufacture of articles at present made abroad, and will be pleased to hear from firms desiring such work executed. 6911

Locomotive Traversers
(ELECTRIC). 7169
S. H. HEYWOOD & CO., LTD.,
REDDISH.

Dredging Plant
OF ALL DESCRIPTIONS.
FLOATING CRANES. COAL BUNKERING VESSELS.
Werf Conrad, HAARLEM, HOLLAND,
Agents: MARINE WORKS, LTD., FRIARS HOUSE, 39-41, NEW BROAD ST., LONDON, E.C. 2.
See half-page Advert. last week and next week. 7520

Centrifugals.
Pott, Cassels & Williamson,
MOTHERWELL, SCOTLAND. 7940
See half-page Advertisement page 98, Oct. 3.

The Manchester Steam Users' Association.

For the prevention of Steam Boiler Explosions and for the Attainment of Economy in the Application of Steam. 9, Mount Street, Manchester.
Chief Engineer: C. E. Stromeyer, M.I.C.E.
Founded 1854 by Sir William Fairbairn.
Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 7479

The National Foremen's Association of the Engineering and Allied Trades.

(Registered under the Trade Union Act.)

An Association specially formed to look after the interests of Foremen on their Supervisory Capacity. A 830

All communications to— Head Offices—
H. W. Reid, 81, High Holborn
General Secretary. London, W.C. 1.

Inst. C.E. Exams.—Over 300

successes by Correspondence Coaching. Several prizes. Sec. "Q" now prepared. (Designs, Specifications and Quantities). A few vacancies open.—Address, 7434 Offices of Engineering.

Correspondence Tuition.—

B.Sc., Inst. C.E., Inst. M.E.; also Single Subjects by Honours B.Sc., A.M.I.C.E., etc. Fees moderate.—Address, 7879, Offices of Engineering.

Inst. C.E., I. Mech. E., B.Sc.,

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Inst.C.E., Inst.Mech.E., and

all Engineering Exams.—A Practical Engineer, A.M.I.C.E., &c. (recently demobilised), has now resumed coaching for above by Correspondence, after 11 years' highly successful pre-war experience. Separate subjects may be taken. Excellent testimonials. Fees moderate.—Address, A 608, Offices of Engineering.

Engineering Special Classes.

Marine & Aero Engines, Alternating Currents, Wireless Course, Ferro-Concrete, Refrigeration, Pract. Maths. and Calculus.—Pennington's, University Tutors, 284, Oxford Rd., Manchester.

TENDERS.

Tenders Invited for Quantities

of STEAM WINCHES. Must undertake prompt delivery. — Address, WINCHES, Wm. Porteous & Co., Advertising Agents, Glasgow. B 169

G. R.

MINISTRY OF MUNITIONS.

BY DIRECTION OF THE DISPOSAL BOARD (Plant and Machinery Section).

For Sale by Tender:—

One Triple-Expansion MARINE ENGINE, as for Patrol Gun Boats, cylinders 16 in., 26 in., 44 in., stroke 26 in., r.p.m. 180, I.H.P. 1400.

For Tender Form and Permit to View apply to the CONTROLLER, D.B.I.e., Charing Cross Embankment Buildings, W.C. 2.

Note.—*Surplus*, price 3d. The Official List of Government Property for sale. Published twice monthly. On sale everywhere. B 63

G. R.

MINISTRY OF MUNITIONS.
BY DIRECTION OF THE DISPOSAL BOARD.
(Plant and Machinery Section).

TRAWLER ENGINES.
FOR SALE BY TENDER.

Tenders are Invited for Two

Mersey type TRAWLER ENGINES, triple expansion, surface condensers, complete with propeller and shafting. Cylinders 18 in. by 29 in. by 37 in., stroke 26 in. Indicated horse power 600, working pressure 200 lb. per sq. in.

Tenders close Ten a.m., 8th November, 1919.

For Tenders and Permit to View apply to the CONTROLLER, D.B.I.e., Charing Cross Embankment Buildings, W.C. 2.

Note.—*Surplus*, price 3d., the Official List of Government Property for sale. Published twice monthly. On sale everywhere. B 62

THE SOUTH INDIAN RAILWAY COMPANY, LIMITED,
are prepared to receive

Tenders for the Supply of

1. 902 PAIRS WHEELS and AXLES (894 Prs. for Metre Gauge Rolling Stocks, 208 Prs. for Broad Gauge Rolling Stock).
2. 178 STEEL TYRES for Locomotives.

Specifications and Forms of Tender may be obtained at the Company's offices.

Tenders, addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked "Tenders for Wheels and Axles" or "Tenders for Locomotive Tyres," must be left with the undersigned not later than Noon on Tuesday, the 18th November, 1919.

A charge, which will not be returned, will be made of 20s. for each copy of Specification No. 1, and 10s. for each copy of Specification No. 2. Copies of the drawings may be obtained at the Office of Robert White, Esq., M.Inst.C.E., Consulting Engineer to the Company, 3, Victoria Street, Westminster, S.W. 1.

By Order,
W. B. REYNOLDS,
for Managing Director.

Finsbury Pavement House,
London, E.C. 2,
20th October, 1919. B 158

COUNTY COUNCIL, TIPPERARY, N.R.
(North Riding) invite

Tenders for the Supply of the

Undermentioned MACHINERY and ROAD APPLIANCES:—

No. 5. Five-ton Compound Steam MOTOR TRACTORS, fitted with pump, injector, winding drum and rope, water elevator and hose, with awning full length of engine, 12 in. wide driving wheels, and governors for driving fixed or stationary machinery.

No. 1. 12 in. by 8 in. Portable STONE BREAKER, with tilting screen, punched with ½ in. and 2 in. round holes and an outer steel gauze for separating the dust.

No. 3. Three-bunk SLEEPING VANS, with top ventilator complete, without bedding, and fitted with springs, coal bunk, &c., &c.

No. 4. Six-ton End-tipping WAGONS, body 8 ft. 9 in., 6 ft. wide, and 2 ft. deep, complete, bottom sheeted with ¼ in. steel.

No. 1. 250-gallon WATER CART, 4 in. bore pump, suction hose, detachable drawbar for shafts, &c.

Above machinery to be similar in every way to that already in use by the County Council, Tipperary, N.R., and to be tendered for in accordance with the Conditions, which may be seen at the County Surveyor's Office, Court House, Nenagh, Co. Tipperary, any day up to Saturday, 15th November next, between the hours of 10.30 a.m. and four o'clock p.m.

Contractor to state date of delivery in his Tender.

Tenders to be lodged in the Office of the Secretary of the County Council, Tipperary, N.R., Court House, Nenagh, not later than Tuesday, 18th November, 1919. Envelopes to be endorsed "Tender for Machinery."

The lowest or any Tender not necessarily accepted.

The probable number required of each class of machinery is above given, but the County Council reserve to themselves the right of purchasing a lesser or greater number of each at their option.

By order,
R. B. BAYLY,
County Secretary.

Court House, Nenagh. B 6

GREAT NORTHERN RAILWAY COMPANY (IRELAND).

CONTRACTS FOR GENERAL STORES.

The Directors are prepared to receive

Tenders for the Supply of the

undermentioned STORES for Twelve Months, from the 1st January, 1920.

	No. of Form.
Axles and Tyres (Steel)	1
Baskets, Brooms, Brushes, Mats, and Sponges	2
Bolts and Nuts, Studs, Pins, Rivets, and Washers	3
Boxes, Farm and Market Produce ...	4
Brass and Copper Sheets, Plates, Tubes & Wire, Block Tin, Zinc, Spelter, and Patent Metal ...	5
Buckets, Oil Cans, Zinc Sheets, Galvanized Iron Sheets, Emery, &c.	6
Buffers & Axle Guards for Carriages and Wagons, Wagon Hinges, Barrow Frames, &c.... ...	7
Canvas	8
Castings (Ordinary Iron, Firebars, Forgings, Crucibles, Oplinders, & Buffer Stops	9
Cement, Plaster of Paris, Slates, Glazed Ware Pipes, Fire Bricks, Tiles, &c. ...	10
Chain	11
Colours, &c. (ground in oil and Dry) and Hall's Distemper, Wall Paper, &c. ...	12
Drysalteries	13
Electrical Fittings Lamps, &c.	14
Electric Cable and Wire...	15
Electric Light Carbons	16
Explosives, Fog Signals and Carbide of Calcium for Acetylene Gas Lighting ...	17
Fittings Brass, for Gas and Water, Gas Burners, Gunmetal Steam Unions, Rain Water Pipes, &c. ...	19
Gas Mantles	21
Gauges, Steam and Vacuum Brake ...	22
Glass	23
Hammer, &c., Handles, Barrows, Oak Keys, Loading Boards and Scotches	24
Hinges (Wrought Iron and Brass), Locks and Keys, Hardware (Iron and Brass), Closet Basins and Seats, &c.	25
Indiarubber Goods, Loco. Packing, Asbestos, &c. ...	26
Iron Plates, Bars, Angles, Tees, and Forgings (best Staffordshire and Yorkshire)	27
Lamps (Oil) and Brass Carriage Fittings, Oiler Pads, and Enamelled Iron Plates...	28
Lead (ground in oil and dry), Sheet, &c.	29
Leather and Leather Goods, and Balata Belting	30
Nails	31
Overalls, Dungaree and Serge	32
Oilskin Suits	32A
Oils (Burning, Lubricating, &c.)	33
Plates (Steel Boiler), Steel Forgings, Fish Plate Liners, Cast Steel Engine and Tender Wheel Centres, Roof Bars, and Mild Steel Plates, Bars, Angles, Tees, and Channels ...	34
Rope, Twine, Flax, and Hemp Gaskin ...	35
Screws (Iron & Brass), Split Pins, &c. ...	36
Signalling Materials	37
Springs for Engines, Carriages, Wagons, &c.	38
Tin Plates	39
Timber, White American Oak Scantlings, St. John's Spruce Plank, Logs, Planks, Boards, Mouldings, Sheetings, &c.	40
Transfers (Carriage, &c.)	41
Tools (Edge), Saws, Files, Tool Steel, Carriage Keys, Hammers, Shovels, Spades, &c.	42
Tubes and Fittings (Iron), Wire, Wire Work, Panel Pins, Staples, and Point Rodding	43
Tubes (Steel—Galvanized), Cold Drawn Weldless for Boilers	44
Upholstery for Carriages, Curled Hair, Blinds, Rugs, Linoleums, Tape, and Soft Goods	45
Varnishes, Enamel, Black Lacquer, and Sheet Dressing Composition	46
Waste (Cotton), Wick, Sponge Cloths, &c.	47

Tenders must be for the supply of Goods in accordance with the samples, which may be seen at the General Stores Depot, Dundalk, between the hours of Ten a.m. and Four p.m. on each week day except Saturdays.

Tenders, made out on Forms, obtainable from the SECRETARY on payment of One Shilling each, should be sent in under sealed cover endorsed "Tender for Stores," so as to reach the undersigned, not later than Ten a.m. on the 11th November, 1919.

The Directors do not bind themselves to accept the lowest or any Tender.

J. B. STEPHENS, Secretary.

Amiens Street Station,
Dublin.
21st October, 1919. B 161

G. R.

MINISTRY OF MUNITIONS.

BY DIRECTION OF THE DISPOSAL BOARD,

(PLANT AND MACHINERY SECTION.)

For Sale by Public Tender,

MACHINERY AND PLANT. Tenders are invited for the following:—

Hand Power Jib Crane 9 ft., Jib 10 ft. radius, 15 cwt. Mounted on circular table.

One ton Platform Scales on wheels 22 in. square. Portable double ended grinder (emery). Air Compressor by Ingersoll Rand & Co., Type No. 12, 150 lbs. per sq. inch. Air receiver for same, also cooling tank.

One BHP. A.C. 3 phase 50 cycles, Semi-enclosed Motor, 400 volts, direct coupled to 12 in. fan.

Six BHP. A.C. Motor as above with switch and starter but without fan. One Oxygen Acetylene Generator, Cap 20 lbs., with all fittings, also Oxygen cutter with spare nozzles.

Above lying at H.M. Store, Rhor Mills, Bingley, Yorks. Tenders closing, November 26th.

CHILLED ROLLS.

Four Chilled rolls 25 in. dia. by 5 ft. 2 in. long. Footplate for wide rolls. Turning Rest for Sheet Mill.

Lying at The Albert Sheet Iron Co., Ltd., Hill Top, West Bromwich, Birmingham.

Rolling Mills, power feed, will roll from 2 B.A. to ¼ in. Present rolls take ¼ in. and 7/16 in., double friction clutch drive.

Lying at Rotax Motor Accessories, Ltd., Willesden Junction, N.W. Tenders closing, November 26th.

Large number of C.I. Tanks, some galvanized also wood tanks, various sizes. Filter Presses, 24 chambers 24 in. sq. complete with pipes, etc. Mild Steel vessels. Platform weight machines. Air Compressors, Vacuum Pumps. Self landing and delivery hoist, 15 cwt. Electric Fans and numerous other articles.

Lying at H.M. Factory, Sutton Oak. Tenders closing, November 26th.

STEEL TUBING.

About 2500 ft. Lapwelded Steel Tube 3/16 in. thick, with Std. inserted joint for lead and yarn. Various lengths of the following bores: 18 in., 12 in., 4 in. Also a quantity of Bends, Reducers, Cocks, Thimbles.

Lying at H.M. Factory, Victoria Works, Northwich. Tenders closing, November 26th.

Conveyor in dismantled condition, complete with 695 trays, 400ft. double endless chain and rollers. Paint Sprayer by Aerostyle & Lithos, Ltd., complete with 6 HP. Motor and starter. Grouting Machine by Murray Workman & Co., Piping, etc.

Lying at No. 6, N.F.F., Chilwell. Tenders closing November 24th.

Two Gasometers 9ft. dia. x 8 ft. deep single lift.

Lying at Messrs. Ardois Factory, Selby. Tenders closing, November 24th.

Portable Band Conveyors, length 24 ft., fitted with 2½ HP. Motor by Phœnix Mfg. Co., suitable for 220 volts D.C. supply.

Stacking Machine, 36 in., fitted with two 15 HP. Siemens Motors suitable for 220 volts, D.C. supply. Stacking height 12 ft. 0 ins.

Tenders closing, November 26th. In charge Shipping Officer, R.A.S.C., West Side, Royal Docks, Grimsby.

MOULDING MACHINES.

Two Moulding Machines for hollow pellets, each fitted with 102 moulds. Moulds contained in troughs of three rows of 17 each.

One machine fitted with two driving plates for ejecting pellets from moulds. These have been used for moulding T.N.T., but should be suitable for numerous other kinds of work.

Lying at the works of Mr. R. Cowles, Ivy Road, Hounslow. Tenders closing November 26th.

Three Cameron Slitters and rewinders for cutting fabric. Eighty cutter wheels, serrated edges.

One Unreeling, Folding and Re-winding Machine complete with motor and starter.

Lying at 44, Chichester Street, Belfast. Tenders closing November 26th.

LAUNDRY PLANT.

12 Frugal Gas Irons with bars, etc.
One Rotary Washer, 24 Wringing Machines.
Three Hydro Extractors, Mangles, Presses and other plant.

Lying at Nottingham, Coventry and Leeds. Tenders closing November 26th.

ELECTRIC COPIERS.

Five Shaw's Continuous (double) Electric Copiers.
Two Hall's do. do. do.
One Drying Machine.
Three American Washing and Drying Machines.

Lying at Hotel Cecil, London. Tenders closing November 24th.

100 Steel Jacks, 20 tons.

Lying at Woolwich. Tenders closing November 24th.

GASHOLDERS AND TANKS.

Two, each 500,000 cub. ft. capacity, complete with spiral guides, carriages, etc. Inner lift 105 ft. × 30 ft. deep. Outer lift 107 ft. 6 ins. × 30 ft. deep. Inlet and outlet pipes 12 ins. dia. Tanks complete with platforms, etc.

Lying at works of Messrs. Samuel Cutler & Sons, Ltd., Providence Iron Works, London, E. Tenders closing November 10th.

All Tenders must be received not later than Ten a.m. on the date stated.

Particulars of the above, together with permits to view can be had on application to the Controller, D.E.I. (E), Charing Cross Embankment Buildings, London, W.C.2.

Note.—For particulars of other Government property for sale see "Surplus," price 3d., at all bookstalls; or by quarterly subscription of 2/- post free, payable in advance to the Director of Publicity, Ministry of Munitions, Whitehall Place, London, S.W.1. B 159

AUSTRALIAN IMPERIAL FORCES DISPOSALS BOARD.

Tenders are Invited for the

PURCHASE of the following:—
2a ROBSON MILLING MACHINE.

One Universal Milling Machine, longitudinal movement 25 in., traverse movement 8½ in., vertical movement 18½ in., spindle B. & S.T. taper hole with ⅞ in. hole through table, 46 in. by 10 in. complete with 10 in. swing universal. Dividing head, vertical milling attachment, 1 in. chain arbor and spacing collars, intermediate arm, two-speed countershaft, necessary handles and spanners.

Patent safety feed reverse motion pump fittings for use on above machine.

Also 3 in. and 3 in. Chuck, back centre Vice, Tool Post, Cutters ½ in. by 6 in., ¼ in. by 4 in., ½ in. by 6 in., ¾ in. by 4 in., 1 in. by 4 in., 2 in. by 4 in., 3 in. by 4 in., and two Mitre Cutters, right and left hand.

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Tenders must be received not later than November 3rd, at the above address. B 150

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JUNIOR LABORATORY DEMONSTRATOR. Applications are invited for the above whole-time appointment for which good workshop experience is essential. Salary £300 per annum inclusive. For conditions and form of application, which must be returned not later than the 3rd November, 1919, apply by letter to— B 147

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Head Master ... ... Mr. R. Warriner.

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the POSITION of MASTER in Engineering Subjects in the above School. Candidates must possess a degree in engineering, or an equivalent qualification, together with works, drawing office and some teaching experience.

Salary scale, £180 by £10 to £220, and then by £15 to £370, but years of service after 21 years of age, either in works or teaching, will count in fixing the initial salary, *e.g.*, with ten years service the salary would begin at £310 per annum.

Applications, accompanied with three recent testimonials or references, must be made on forms to be obtained from the undersigned and returned on or before 17th November, to

HERBERT REED,
Education Offices, Chief Education Officer.
15, John Street, Sunderland,
21st October, 1919. B 94

UNIVERSITY OF DURHAM.

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(1) Will be a permanent appointment, at a salary of £290 per annum, rising by yearly increments of £25 to £400.

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Duties in both appointments to commence early in November.

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THE REGISTRAR,
Armstrong College,
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THE TECHNICAL COLLEGE, LOUGHBOROUGH.

H. SCHOFIELD, M.B.E., B.Sc. (Hons.), London; A.R.C.Sc., London Principal.

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(1) A LECTURER IN MECHANICAL ENGINEERING.
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Applicants should possess a University Degree or its equivalent, and should have had practical experience in recognised Engineering Works. Salary £250 per annum, rising by increments of £25 per annum to £450; further increments being considered subject to satisfactory service.

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Applications, with copies of not more than three recent testimonials, to be submitted not later than the 1st November to the PRINCIPAL, from whom Forms of Application and further particulars may be obtained.

W. A. BROCKINGTON,
Director of Education. B 89

FLAME VELOCITY IN INFLAMMABLE GASES.

By J. D. MORGAN.

THE object in the following is to suggest and examine a possible simple relationship between flame velocity and pressure during the combustion of inflammable gases. The proposition is that flame velocity is proportional to gas pressure.

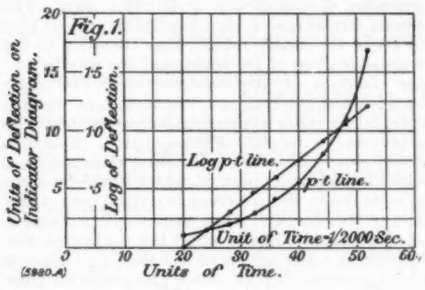
Expressed symbolically,

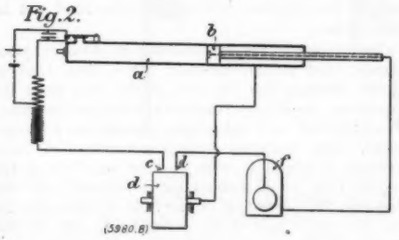
$$u = a\,p \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

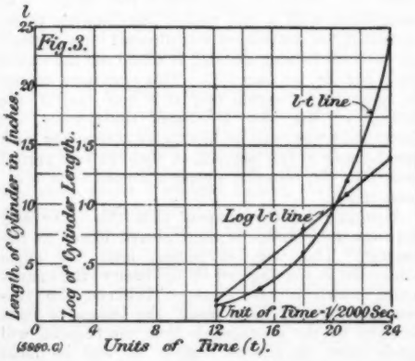
where

u = flame velocity.
a = constant.
p = pressure.

1. The simplest case to consider is that of combustion in a long cylinder closed at both ends and provided at one end with an igniting spark gap; the combustion being assumed to be relatively slow so that p can be considered to have the same value in all parts of the cylinder.







At any instant during the movement of the flame

$$p = \frac{\beta\,Q}{\phi\,(l)} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

where

β = constant depending on the gas.
Q = quantity of heat produced.
$\phi\,(l)$ = some function depending on the cylinder length.

From (2):

$$\frac{d\,p}{d\,t} = \frac{\beta}{\phi\,(l)} \cdot \frac{d\,Q}{d\,t} \quad . \quad . \quad . \quad . \quad (3)$$

Since $\frac{d\,Q}{d\,t}$ is proportional to u, and u is supposed to equal $a\,p$, (3) can be written

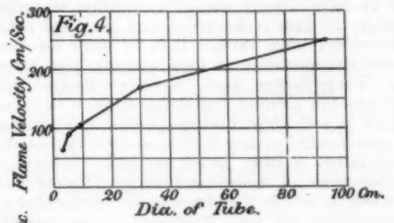
$$\frac{d\,p}{d\,t} = \frac{A}{\phi\,(l)}\,p$$

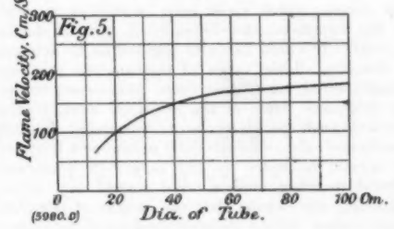
where A is an inclusive term for the various constants. It follows that:

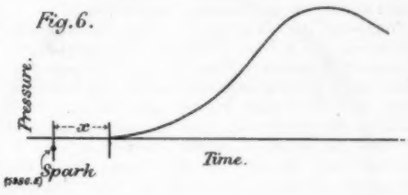
$$p = p_0\,\epsilon^{\frac{A\,t}{\phi\,l}} \quad . \quad . \quad . \quad . \quad (4)$$

The suggestion that $u = a\,p$, is tentatively proved if an actual $p - t$ diagram can be identified with (4).

Fig. 1 is redrawn from measurements of a portion of a diagram produced by the explosion of a mixture of coal-gas and air in a chamber fitted with a diaphragm type indicator. A small initial part of the curve is omitted because of uncertainty as to the true beginning of the curve after the occurrence of the spark, and the terminal portion is omitted because of its change of form near maximum pressure due to the cooling action of the cylinder walls on the approaching flame. Pressure and time are given in the units employed in measuring up the original diagram. The actual pressure was not obtained. The unit of time corresponds to 0·0005 second.* From a previous investigation it was known that the deflections of the corrugated indicator diaphragm were proportional to pressure over the range of movement involved. In Fig. 1







$\log p$ is also plotted against t. From this line it is clear that:

$$\log p + \log C = \delta\,t,$$

whence the equation of the $p - t$ curve is of the type:

$$p = p_0\,\epsilon^{\delta\,t}$$

The suggestion that $u = a\,p$, therefore appears to be verified.

2. If

$$u = a\,p$$

$$\frac{d\,u}{d\,t} = a\,\frac{d\,p}{d\,t}$$

$$= \frac{a\,\beta}{\phi\,(l)} \cdot \frac{d\,Q}{d\,t} = \frac{A\,u}{\phi\,(l)}$$

whence

$$u = u_0\,\epsilon^{\frac{A\,t}{\phi\,(l)}} \quad . \quad . \quad . \quad . \quad (5)$$

Keeping the composition and initial pressure of the gas mixture constant, it follows from (4) and (5) that the time of reaching the final pressure and final velocity will differ with the length of the cylinder, although the final pressure and velocity will be the same for the same gas mixture. To find the relationship between l and t in cylinders with ignition at one end, an experiment involving the apparatus shown in Fig. 2 was arranged. A cylinder (*a*) is provided with a tightly fitting piston *b* carrying an igniting spark gap. At one end of the cylinder is a light valve forming part of the interrupter of the primary circuit of an induction coil arranged to produce a spark at a gap (*c*) over a revolving drum (*d*). The igniting spark gap is in series with a second gap (*l*) over the drum. A magneto (*f*) serves to produce the igniting spark. The passage of the igniting spark is recorded by a spark at (*e*), and the attainment of a fixed small pressure sufficient to lift the valve is recorded by a spark at (*c*). Both sparks produce marks on a smoked strip of paper carried on the drum. Explosions were obtained with the piston fixed at different positions. A typical result is shown in Fig. 3, where cylinder length l is plotted against the time elapsing between the passage of the igniting spark and the production of a predetermined pressure. In the same figure $\log l$ is plotted against t. From this it is evident that l and t are correlated by the expression $\log B\,l = C\,t$, where B and C are constants. Expressed otherwise:

$$\frac{t}{\log B\,l} = \text{a constant} \quad . \quad . \quad (6)$$

For explosions obtained under the conditions specified the $p - t$ equation can be put into the form:

$$p = p_0\,\epsilon^{\frac{A\,t}{\log B\,l}} \quad . \quad . \quad . \quad (7)$$

3. In experimental investigations of flame movements in inflammable gases, much work has been done in measuring what is termed the uniform movement. When gas contained in a tube open at one end and closed at the other is ignited at the open end, it is said that the flame movement for a distance along the tube from the open end is at uniform rate. This movement eventually increases in speed and may in some cases reach a comparatively high velocity at the closed end of the tube. As a close approximation it is doubtless permissible to regard the initial movement as uniform in speed. But from the foregoing it would appear that the motion is not exactly uniform. Throughout its duration the speed continuously increases. The condition for perfectly uniform movement is a constant pressure, and this is not perfectly attainable although it is approached for a certain time when inflammation proceeds from the open end of the tube. Equation (5) shows that there can be no real difference between an explosion proceeding from the open end of the tube and one proceeding from the closed end, although judging from appearances and sound the characters of the two explosions are totally unlike. Mason and Wheeler have shown experimentally (Trans. Chem. Socy., 1917, vol. iii, page 1053) how the speed in the uniform movement varies with the size of the tube. They rightly attribute the differences found to the cooling action of the tube wall. Fig. 4, copied from their paper, shows the observed relationship between flame velocity during the uniform period and tube diameter. The general character of their results are in agreement with a conclusion deducible from the expression $u = a\,p$. Imagine a cylinder with non-conducting ends and a conducting periphery. The pressure produced by the complete inflammation of a quantity of gas in such a cylinder can be approximately expressed as:

$$p = \frac{c\,(Q - q)}{r^2} \quad . \quad . \quad . \quad (8)$$

where

Q = heat generated.
q = heat lost.
r = radius of cylinder.
c = constant.

But $Q \propto r^2$ and $q \propto r$. Therefore (8) can be expressed in the form:

$$p\left(\text{or } u\right) = \gamma - \frac{\delta}{r} \quad . \quad . \quad . \quad . \quad (9)$$

where γ and δ are constants.

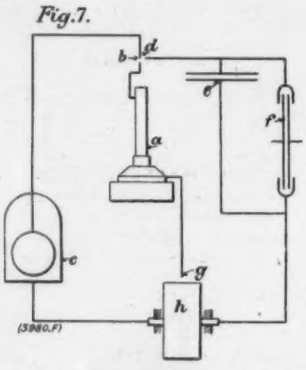
Taking arbitrary figures and plotting the relation between u and r given by (9) a curve, as shown in Fig. 5, is obtained. It will be observed that its general character is very much the same as that found by Mason and Wheeler. As already indicated, cooling has a modifying effect on the $p - t$ diagram, particularly when the flame approaches the walls of the explosion chamber. Near the region of maximum pressure the curves depart considerably from the forms covered by (4), the difference being manifest in a rounding off of the crest of the curves, particularly in the cases of slow-burning mixtures;

4. Regarding the initial part of the $p - t$ diagram, it is a well-known fact that when a spark record is also made the instant of ignition does not coincide

* Time is measured from the occurrence of the igniting spark.

with the apparent origin of the pressure. A typical diagram is shown in Fig. 6. The question arises as to whether the no-pressure interval (x) is due to the gas or the indicator. A conclusive answer is not easily obtained, but a variety of facts point to the indicator as the cause. It is obviously unlikely that there is any appreciable interval between the passage of the igniting spark and the production of flame. To test the matter an experiment was performed in the following manner: A bunsen burner a (Fig. 7), mounted on an insulating stand, is provided with an igniting spark gap (b) connected to a magneto (c). Adjacent to the

Fig.7.



gap (b) is another gap (d) connected to a condenser (e), which can be charged from a Wimshurst machine (f). The burner is connected to another spark gap (g) over a rotating drum (h), this gap being common to the circuits of the magneto and condenser. The gap (d) is so adjusted that it is not affected by the passage of a small spark at (b). When the gas is turned on and a single spark produced by the magneto, the gas is ignited and the flame causes the condenser to discharge across (d). If the two sparks resulting at (g) are sufficiently separated two records will be obtained on the smoked paper strip carried by the drum. It was found that two spark records separated by a time interval of 0·0006 second could be identified. In the limit of adjustment at which a spark could be produced at (b) without discharging the condenser across (d), a single dot was obtained on the strip when the gas was ignited. Consequently the flame resulting from ignition must have spread sufficiently to cause a discharge of the condenser across the gap (d) in an interval less than 0·0006 second. Seeing that this interval is much smaller than the no-pressure intervals found in $p - t$ diagrams, obtained by explosion of gas of the same kind as that used in the above experiment, it may be assumed that flame is in existence for practically the whole of the no-pressure interval. Wheeler (Trans. Chem. Socy., 1918, vol. cxiii, page 854) has formed a similar opinion from his measurements, and in his paper he states that in the spherical chamber used by him the flame had filled one-fifth of the chamber before any indication of pressure was given on his $p - t$ diagrams. It is scarcely conceivable that such a flame would produce no-pressure and it must be concluded that in his case, as in others of a like kind, the no-pressure interval was due to lack of responsiveness in the $p - t$ indicator. Using two different kinds of indicators, one an ordinary diaphragm indicator on a closed vessel, and the other an oscillatory vane adapted to record vibration pressures in an open-ended tube, the writer found with a certain coal-gas mixture a no-pressure interval of 0·004 second in the first case, and an interval of 0·002 second in the second case using a weaker gas mixture. This difference is attributable solely to the indicator. It appears reasonable to conclude therefore that the no-pressure intervals found in $p - t$ diagrams are not due to the absence of pressure in the inflamed gas. Assuming this to be the case the true $p - t$ curve must be considered to have its origin at the instant of passage of the spark. If a curve be calculated from equation (4) it will be found to rise very slowly at first, and it is easy to understand that indicators designed to resist the maximum pressure of the explosion would not be capable of indicating the initial pressures.

On reflection it would appear that equations (4) and (5) are related to the chemists' law of mass action. If that is so, then the suggestion advanced in this article is supported by a wider basis of evidence than is found in the experiments cited. It is hoped in a future article to develop the theory further and show its application to explosions in long tubes.

THE WORKS AND PRODUCTS OF MESSRS. BARR AND STROUD, LIMITED.

Continued from page 365.

Having dealt with the organisation and equipment of their works, we now propose to say something of Messrs. Barr and Stroud's manufactures. As we have already stated, in addition to range-finders the firm make fire-control gear and other accessories, while further lines of work are now under consideration, or have actually been taken up. Range-finders have, however, always been the essential product and *raison d'être* of the firm, and it is with them that we propose first to deal. A considerable variety both in size and type of the instruments is built, owing partly to the natural development of design and partly to the different services for which they have to be made suitable. These points are well illustrated by the entirely new designs which have been created as a result of the enormous development of aircraft during the war. It would be quite impossible to attempt to describe all the types of instruments that are manufactured, and it is quite unnecessary to try. An adequate idea of the beautiful work turned out will best be given by a reasonably detailed description of a characteristic instrument followed by special reference to any points of particular interest in other models. We should say before beginning the details that the output of complete range-finders during the war reached at the busiest period about 800 instruments a month.

Premising our description of a characteristic instrument by a brief reference to principles, we may direct attention to Figs. 26 and 27, on page 537. These show in diagrammatic outline the principal parts of a Barr and Stroud range-finder. It is probably needless to say that the instrument is of the type by which a single observer is able to ascertain the distance of any object from the instrument, if the object is within the distance limits for which the instrument is set. It is thus in every way distinct from rangefinders by which two observers situated at either end of a base of known length determine the distance of an object by what is practically a trigonometrical survey. As will be seen from the figures, the rangefinder consists essentially of a pair of tubes, one inside the other, carrying a number of optical parts. The outer tube is of stout construction, and carries and protects all the inner parts from mechanical damage. Considering for the moment the instrument in its simplest possible form, the essential optical parts are the right and left double reflectors (called for convenience "pentagonals") fixed at either end of the outer tube, the objectives fixed at either end of the frame tube, the eyepiece prisms fixed at the centre of the frame tube, the deflecting prism, and the right eyepiece.

The rangefinder may be looked on as a pair of telescopes with a common eyepiece, mounted together on a frame. The common eyepiece is carried at the centre and the objectives at the ends of the inner tube, as already referred to. The telescopes receive images of a distant object through the openings in the outer tube after reflection by the pentagonals, which direct them through the objectives in the manner indicated by the fine full lines in Fig. 26. Passing through the objectives the images fall on to the eyepiece prisms in the centre of the frame tube and are reflected into the eyepiece. In this way the images of the two telescopes are superposed in a single eye-piece. Considering the instrument in this way as two telescopes, it will be seen that the only purpose served by the two pentagonals and the eyepiece prisms is to alter the direction of the two beams of light and bring them together in the eyepiece. This, as a matter of fact, will be found to be the only duty of the pentagonals when the instrument is considered more fully as a rangefinder. The eyepiece prisms, however, have further duties which we will refer to later.

Considering the pentagonals for a moment, it will be clear that the only service required of them is the reflection of a beam at right angles to itself, and that this could equally well be performed by a plane reflector, or mirror, set at 45 deg. In early rangefinders such a mirror, made of speculum metal, was used, but the pentagonal prism has two advantages over it. The first of these is that in a plane metal mirror the reflecting surface is exposed and so is liable to mechanical damage or corrosion, while in the case of the pentagonal prism the reflecting surfaces are inside and next to the glass and can be protected on the back by copper deposited electrolytically or in other ways. The second advantage—a very important one—is that owing to the double reflection an alteration in the angular position of the pentagonal has no effect on the direction of the emergent ray. The angle between the entering and emerging rays remains constant for quite a large angular movement of the pentagonal in the plane of triangulation. This condition clearly does not hold with a plane mirror, a slight angular movement of which would be sufficient to throw the emergent ray right out of the field of the objective, and a microscopic movement of which would seriously affect the readings of the instrument. The advantages of these two features of the pentagonal prism from the points of view both of manufacture and maintenance need not be insisted on.

Coming now to the second function of the eyepiece prisms, that is the function other than that of merely altering the direction of the rays from the objectives, we at once come to the feature by means of which the two telescopes constitute a range-finder. The eyepiece prisms consist of a combination of prisms so built up that only half of the field of view of each telescope is reflected into the eyepiece, the lower half of the field of one telescope and the upper half of the other being seen by the observer. These two half fields come contiguous to each other with a fine visible line between them, so that if the instrument was directed on a flagstaff an observer looking through it would see the object as in Fig. 28, on page 537. This statement should be qualified by saying that it is true only if the setting of the two telescopes constituting the instrument was such as to exactly correspond with the distance of the flagstaff, so that the two partial images in the common eyepiece formed one complete image.

Assuming for the moment that this is so and that the rangefinder is then moved closer to the flagstaff. This will, of course, alter the angle subtended at the flagstaff by the base of the instrument, which is the distance between the two pentagonals, and as a result the beams of light received by the pentagonals from the flagstaff will reach them at altered angles. It will be most convenient to assume that the direction of one beam only is altered, which will be the case if the instrument when moved closer to the flagstaff is kept at a constant angle with the other beam. Referring to Fig. 26 and assuming that the right pentagonal receives its beam of light at the same angle as before, as indicated by the full line, then the left pentagonal will receive its beam at a new angle, as indicated by the fine broken line. The effect of this will be that the beam will pass through the objective and eyepiece prisms at a different angle and there will be a shifting of the image in the field of view. Instead of the flagstaff being seen as in Fig. 28, it will appear as in Fig. 29

It will be clear that the amount of shifting of the left-hand image in Fig. 29 will be a function of the amount by which the instrument has approached the flagstaff, and by suitable scaling the amount of approach might be read off directly from the shifted image. This direct reading is not as a matter of fact employed as it would be inconvenient, and would not admit of the necessary accuracy, but the simple explanation we have given illustrates in essence the method by which the instrument is used to find the range of distant objects. If the

first position of the images, as shown in Fig. 28, corresponds to an object at known distance determined at the first setting of the rangefinder, then, within the working limits, the distance of all other objects could be determined by the amount of shift of their images when they were observed.

It will be fairly obvious at this stage that instead of attempting to read off the distance of an object directly from the shift of the image, some mechanism might be employed which could so adjust the optical parts that the two half images would again be brought to coincidence. The movement of the mechanism would thus give a measure of the distance. This is the method which is actually employed.

This measurement of range by bringing the two images to coincidence has a practical aspect to which we have not yet referred. In the case we have considered so far we have dealt with a flagstaff. This is a simple object, and as illustrated in Fig. 29 the measurement of range by measuring the shift of the half image might appear a workable method. In practice, however, one has to deal to a considerable extent with complex objects, and when taking the range, for instance, of a clump of trees, it will be fairly clear that the bringing of the images into coincidence is a much simpler and more accurate operation than attempting to read off the shift.

In practice it is usual, naturally, to make the conditions as simple as possible, and if a simple definite object like a flagstaff forms part of the object which is being viewed, then it is on the simple part that the range is taken. This is illustrated in Fig. 30, which shows a warship as seen through a rangefinder, the instrument having been placed so that the range can be taken on the mast-head.

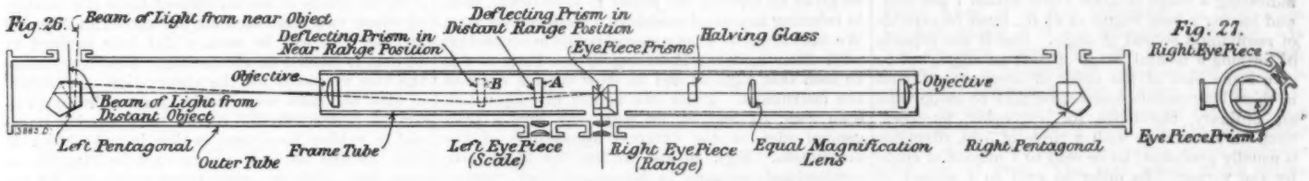
Turning now to the mechanism by which coincidence is obtained, it will be evident that what is required is some method by means of which the beam of light leaving the left pentagonal, and shown by a broken line in Fig. 26, can be caused to reach the eyepiece at the same angle and in the same position as that shown by the full line. In rangefinders having plain end-mirrors instead of pentagonal prisms this diversion of the beam can be carried out by angling the mirror. This method has been used, but is not applicable to instruments with pentagonals, and is in any case quite superseded. We mention it only because its simplicity assists a general explanation of the action of a rangefinder and also because its essential defect accentuates the advantages of the method which is actually used. Anything else apart, the defect of the angling mirror method of obtaining coincidence is that the complete range of measurement of the instrument is contained within an excessively small angle.

It will be quite evident from Fig. 26, assuming the pentagonal replaced by a plane mirror, that the movement of the reflecting mirror through quite a small angle would swing the ray altogether out of the field of the objective. In consequence of this a multiplying device of some kind would be necessary to measure the small angular movement corresponding with the accuracy of range measurement desired, and this multiplying device would carry future possibilities of error.

The actual method of obtaining coincidence in Barr and Stroud rangefinders is by means of a deflecting prism shown in two positions, A and B, in Fig. 26. The deflecting prism is of very small deviating angle and is placed as shown directly in the path of the beam from the left pentagonal to the eyepiece prisms. The prism can be moved to and fro along the inner tube. If the prism were a simple piece of glass with parallel sides such a movement along the tube would have no effect on the image, but the prism bends the beam of light so that the direction of the beam reaching the eye-piece prisms is altered. The movement of the prism thus forms a method of bringing the images into coincidence, as is illustrated by the broken line representing a beam in the left-hand half of Fig. 26. By making the angle of the prism very small the total movement demanded from it for full adjustment of the image in both directions is considerable, so that a large total movement is obtained. This is the movement which has to be graduated in some way to give the scale of ranges for the instrument and the advantage of the large movement in minimising error will be obvious. The simplest method of utilising the motion of the deflecting prism is to attach the range scale directly to it and to read off the range against a fixed mark. The length of travel of the prism is sufficient to give a quite open scale. This simple arrangement is used in many of the various models of rangefinders built, and is indicated in Fig. 26 where the left-hand eyepiece is arranged to read the scale and the right-hand one to view the images. With very little practice it is easy to use an instrument so arranged, the right eye viewing the distant object and the left eye reading off the distance on the scale.

The use of the deflecting prism in rangefinders owes its introduction to Messrs. Barr and Stroud, and although it now appears a fairly obvious device, at the time it was first used it was little less than revolutionary. To this idea belongs the success of Messrs. Barr and Stroud's instrument. The double eyepiece, one eye taking the range and the other reading the scale, is also due to the firm.

There are one or two other details in connection with the instrument to which we should refer before proceeding further. The first of these is the halving glass, which is shown in the figure. This is merely a piece of plain glass mounted in the line of the beam on one side of the instrument and arranged so that it can be tilted. The purpose of the attachment is to furnish a method of adjusting the "halving" of the image. If the optical parts are not correctly placed in reference one to another, or if they become misplaced by any means the two halves of the image may move relatively to each other and one may get duplication of the image as in Fig. 31 or deficiency as in Fig. 32. The tilting of the halving glass causes one image to move up or down and corrects this error. Another adjusting device fitted to the instrument is the equal-magnification lens, also shown in Fig. 26. This is merely for the purpose of adjusting the magnification of one side of the system in case there should be a slight difference in the magnifying power of the two telescopes forming the rangefinder.



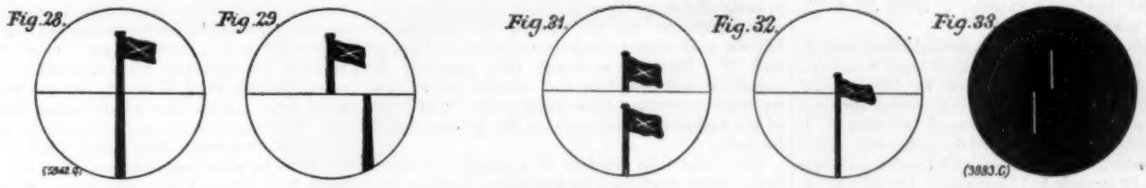


FIG. 30.

There is a further optical device fitted to the instrument, which, however, is not indicated in Fig. 26. This consists of two astigmatiser lenses which can be moved into the paths of the beam of light. They are small cylindrical lenses having the axes of the cylinder horizontal and transverse to the direction of the beam. The effect of such a lense is practically to put the object viewed greatly out of focus vertically, while not altering its focus horizontally. The object of the device is to render the instrument more accurate and convenient when it is being used to determine the distance of a small or indefinite object such as a distant light or a small bush. It will be evident that a small object like a point of light cannot be bisected by the separating line in the field of vision, and that it would be very difficult to determine when the half images were in coincidence. The effect of astigmatising is to draw the point, or small object, out into a vertical line when rangefinding may proceed in the usual way and with no difficulty. Fig. 33 illustrates the field of view at night with the astigmatiser in use, when the instrument is directed upon a distant point of light such as a star.

Before proceeding to further details it will be of interest to say something of the accuracy obtained with Barr and Stroud rangefinders and the optical problems which the attainment of that accuracy raises. Apart from questions of the state of the atmosphere and other external conditions of working which are incidental, the accuracy of any short base rangefinder of this type will depend on the distance between the pentagonals (known as the base length) and the smallness of the angle which the instrument is capable of detecting. These essential conditions of accuracy are fairly obvious. The instrument determines distances by indirectly measuring the angle of parallax, and the longer the base the greater will be that angle. The second condition may be illustrated from Fig. 26. If the beam of light from a near object, shown by a broken line at the left-hand side of the figure, be taken as coming from an object at the minimum distance at which the instrument is intended to read, then it is clear that the whole range of measurement of the instrument, from its minimum to infinity, must be contained in the angle between this broken line

and a corresponding line representing a beam from infinity. This corresponding line, which is approximately represented by the full line on the figure, would be parallel to the line representing the beam reaching the right pentagonal, and it is clear that the angle referred to is equal to the angle of parallax for the object at a minimum distance.

If a rangefinder has a base length of 4·5 ft. and the minimum distance it is designed to measure is 250 yards, then the angle available for subdivision to indicate the series of distances between 250 yards and infinity, is 20 minutes. If the base is 9 ft. and the minimum distance 1,000 yards, the angle is only 10 minutes; with a 15-ft. base it becomes 17 minutes. It will be clear that the accuracy of a rangefinder decreases as the distance of the object observed increases. The error varies as the square of the distance. An instrument with an error of 1 per cent. at 3,000 yards, can work within ½ per cent. at 1,000 yards and $\frac{1}{10}$ per cent. at 300 yards. Such an instrument, i.e., one capable of indicating a range of 3,000 yards within 1 per cent. and having a base length of 4½ ft., must be capable of resolving a second of angle. One is not capable of forming a mental image of such an angle, but to give some idea of the order of accuracy attained in these instruments comparison may be made with an ordinary theodolite for surveying purposes. Such an instrument with a circle of 5 in. diameter is usually graduated to be read to 1 minute of angle by the vernier. In order to read to 1 second of angle with the same facility, a circle 25 ft. in diameter would be required.

Although Barr and Stroud rangefinders are capable of resolving angles much smaller than a second, such angles cannot be resolved by the unaided human eye, and magnification is necessary for their appreciation. From the makers' experience it would appear that the unaided eye using the coincidence method of observation can resolve an angle of about 12 seconds to 15 seconds. Accordingly to deal with angles of ½ second a magnification of 30 diameters becomes necessary. A smaller magnification leads to a lower order of accuracy, so that in the magnifying power we have the second factor determining the accuracy of rangefinders. It should be said here that it is only in rangefinders of the coincidence type, such as we have described above, that an accuracy of 12 seconds to 15 seconds for the human eye is found to be attainable. If overlapping images are employed or a stereoscopic method the order of accuracy is considerably lower. There are various alternatives to the coincidence erect image such as is illustrated in Fig. 30. In one class of coincidence instrument, which is used to a considerable extent for military purposes, one of the halves of the image is inverted, so that instead of the whole of the object under view being seen, divided into two parts by a fine line, the upper or lower part of the object only is seen upright in one half of the field and inverted in the other. This inverted image type of instrument is considered by many users to lead to greater accuracy when objects of irregular form, or but ill-defined, have to be dealt with. Any want of lateral symmetry is more clearly brought out when a tree, for instance, is being observed by inverting half the image than by merely dividing it by a horizontal line. The inversion of the half image is carried out in the eyepiece prisms.

In connection with the question of the accuracy of Messrs. Barr and Stroud's rangefinders we would like to make a short quotation from an article by Mr. J. W. French dealing with the rangefinder work at the Battle of Jutland. The whole of the instruments on the British ships were of Barr and Stroud manufacture. "At the commencement of the war no British battleship carried a rangefinder of greater base than 9 ft. This base had been decided upon in 1904, when the maximum effective range for the opening of fire was generally assumed to be not greater than about 6,000 yards. In the Battle of Jutland fire was carried out at ranges above 20,000 yards. The Iron Duke, which carried only 9-ft. rangefinders, opened fire at 12,000 yards. The rangefinders were, therefore, called upon to perform a duty at least four times as onerous as that for which they were originally designed. . . . Notwithstanding the use of 9-ft. rangefinders in association with guns, the power of which has been so greatly developed during the last twelve years, the British Fleet at the Battle of Jutland defeated the German ships, which there is good reason to believe were equipped with rangefinders of 20-ft. base and, probably, to some extent 33-ft. base. In such circumstances it is not surprising that the German rangefinding was excellent; it is more surprising that it was not very much better, and that its excellence was confined to the first stage of the action."*

Turning now to a consideration of a Barr and Stroud rangefinder in greater detail, we may refer to Figs. 34 to 43, on Plate XXXI, which illustrate an FQ type instrument. The letters FQ are merely makers' references to a class. They refer to a form of instrument designed for naval and fortress service which is made with base lengths of 12 ft., 9 ft., 6 ft. 6 in. (2 metres), and 4 ft. 6 in. Other classes of naval and fortress instruments are also built, but as we have already said a better idea of the instruments will be given by treating one model in some detail, than in referring to several models in a more general way. We will later refer to any special points in connection with other models. Referring to the Plate it will be seen that Figs. 34 and 35 show outside views of the instrument. These two figures in conjunction with Figs. 53 and 54, on page 539, give a good general idea of the external appearance of the instrument. Figs. 36 and 37, on the Plate, give longitudinal sections in horizontal and vertical planes. An inspection of these two figures will show that the general method of construction follows that shown diagrammatically in Figs. 26 and 27. There is a frame tube carrying the objectives and deflecting and eyepiece prisms, and an outer protecting tube forming the main frame of the instrument and carrying the pentagonals at its ends.

The outer tube consists of a number of drawn brass tubes reinforced by gun-metal castings, and put together in such a way as to form for the greater part of the length of the instrument a double envelope with an air space between the tubes. At the bearing rings and adjusting heads joints are made in the length of the tubes by filling the air space with machined castings forming connecting pieces. The tubes are soldered and pinned to these castings and the joints are so disposed that in no case is there a break in the inner tube opposite a break in the outer. We referred to the building-up of these outer tubes in connection with our description of the workshops in an earlier article. The instrument, as will be seen from some of the lower figures on Plate XXXI, and also from Figs. 53 and 54, on page 539, is carried in the mounting by two bearings with upper hinged straps. The outer tube carries two bearing rings which lie in these bearings. These bearing rings are made in one with the connecting pieces, as can be seen in Figs. 36 and 37. These figures, in common with Figs. 34 and 35, also show that the left-hand bearing ring is provided with flanges which fit to the cheeks of the fork on the mounting and so prevent the rangefinder moving endwise. No flanges are provided on the right-hand bearing ring, so that the instrument is not constrained. A wooden handle is hinged to the lower side of the outer tube close to the left bearing ring. It serves for rotating the rangefinder in its bearings, controlling it in altitude to suit the motion of a vessel in directing it upon the object under observation. The handle is hinged to facilitate packing.

At each end of the main tube there is a casting carrying a pentagonal. Each casting has a window through which the image of the object under view reaches the pentagonal. The windows are ground optically flat and parallel, and are made of a hard quality of glass so that they are not likely to be scratched during cleaning. Each is provided with a tubular sunshade as is best shown in Fig. 36. The pentagonals are solid glass prisms held in metal frameworks which have the same coefficient of expansion as the glass. This tends to minimise temperature effects. The metal holders are mounted on a three-point suspension and are held down by a strong central spring. The arrangement may be seen in Fig. 37. After adjustment the holders are finally locked in position at the supports. The gun-metal casting, which carries the pentagonal holder, is externally of slightly conical form and fits into a corresponding conical seat turned on the inside of the enlarged end of the rangefinder tube. An end cap which screws on to this main tube forces the pentagonal carrier into its seat. A V-notch and feather is provided to locate the carrier in its correct position. The general lines of the arrangement are clearly shown in Figs. 36 and 37. As will be seen from these figures the enlarged ends of the tube are provided with rotatable cover rings. These rings carry the sunshades already referred to, and when the rangefinder is not in use the rings are rotated so that the sunshades lie at the lower side of the tube. This serves to protect the windows. A further feature of the construction which will be clear from the figures is that an air space is provided all round the pentagonals. This helps to protect them from variations of temperature.

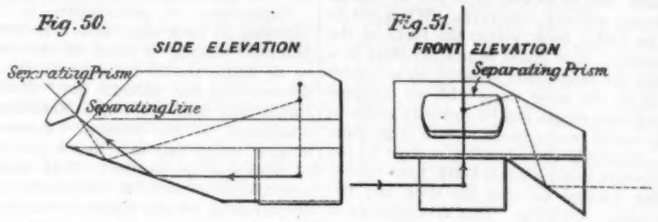
In the centre of the instrument there is a casting, of which two cross-sections are shown in Figs. 38 and 39. As will be seen, a flat face inclined at 45 deg. is formed on the casting. This face carries the two eyepieces for the observation of the field of view and scale respectively, and a third eyepiece for the finder. It also carries the focussing levers and a rubber face-piece, which is not shown in Figs. 38 and 39, but can be seen in Fig. 54, on page 539. This face-piece forms a soft rest for the brow and makes the instrument more comfortable to use, especially when guns are being fired in its vicinity. It also excludes light other than that received through the eyepieces. The main eyepieces are placed 2½ in. apart, but the left eyepiece is of some considerable width horizontally so that the instrument is equally convenient for use by different observers. The range scale is read by the left eye when the images seen by the right eye have been brought into alignment. After a little practice the two eyes can be used alternately or simultaneously for their respective duties, without losing the object from the field of view of the right eye while the scale is being read with the left.

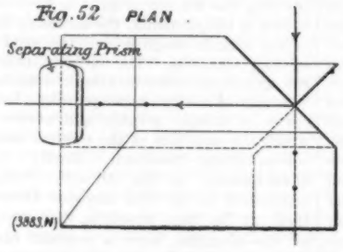
The finder eyepiece is situated immediately under the right eyepiece. To observe the range field the observer looks into the main eyepieces fixed at 45 deg. to the horizontal, but to observe the finder field he has to look vertically downward. This vertical arrangement is found to be more convenient than a horizontal one looking out across the top of the instrument, and has the advantage that it is not necessary to remove the face from the rubber face-piece when using the finder. A prism combination is used with the finder in order to project the image to the vertical eyepiece. It can be seen in Fig. 38, while in Fig. 39 the finder window is shown. The finder has an angular field of 9 deg. and 4 magnifications. The prism combination is made so that in the centre of the finder field there appears a small circle, and when the rangefinder is so directed that the object under observation is brought within this circle, the object appears highly magnified in the range field, the angular field of which is 1 deg. 28 minutes and the magnification usually 28.

To the right of the instrument, and within convenient reach of the observer's right hand, there is fitted a rotatable cover ring, the movement of which is limited by a stop screw. Below this ring are situated the deflecting head and astigmatiser slide, and also the adjusting heads for the correction of coincidence and halving errors. The cover ring has three positions. In one the whole of these operating parts are covered and protected from injury, in another, the position of normal working, the deflecting head and astigmatiser slide are uncovered. In the third position the adjusting heads can be got at. These, of course, are only touched when the instrument has to be adjusted. The deflecting head, as will be seen from Fig. 36, consists of a milled roller. It is rotated by the fingers of the right hand when the instrument is in use, and this rotation traverses the deflecting prism along the frame tube and so adjusts the instrument for range. The rotation at the same time moves the scale, bringing the correct reading opposite the left eyepiece when coincidence is obtained. The deflecting head operates the

* *Nature*, July 24, 1919.

BARR AND STROUD'S RANGEFINDERS.





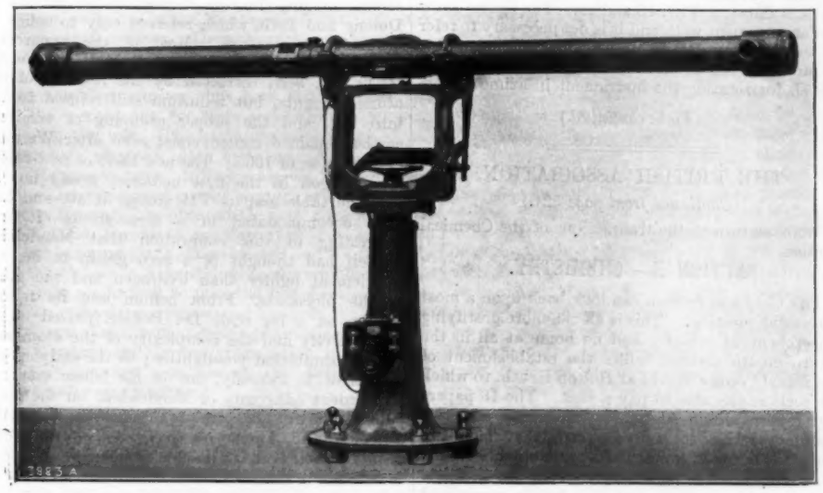


FIG. 53. RANGEFINDER ON NAVAL MOUNTING; FRONT VIEW.

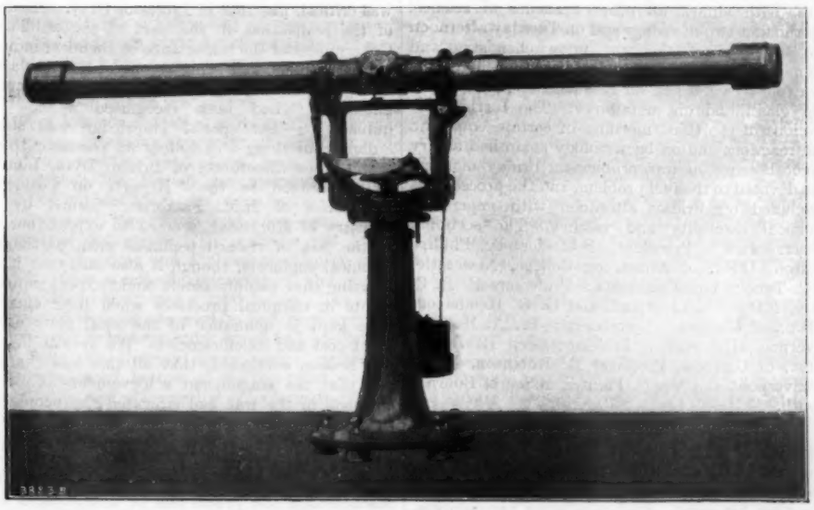


FIG. 54. RANGEFINDER ON NAVAL MOUNTING; REAR VIEW.

scale and prism gear through flexible couplings so that external forces cannot be transmitted from it to the inner frame tube. The rotation of the deflecting head is transmitted to the gearing by a deflecting coupling rod which is clearly shown in Fig. 36. This rod carries two gear wheels at its far end, one of which drives the scale drum and the other the screw which traverses the deflecting prism. The scale is arranged spirally around a drum in order to obtain considerable length and open readings. The drum is clearly to be seen in Figs. 36 and 37, while the means by which it is viewed through the left-hand eyepiece is shown in Fig. 39. As will be seen from this figure it is actually an image of the scale in a reflector which lies in the eyepiece field. The method by which the deflecting prism is traversed by the movement of the same coupling rod which rotates the scale will be understood from Figs. 36 and 37. The arrangement is best seen in the latter figure, which shows the deflecting screw which is rotated by one of the gear wheels on the deflecting rod. The rotation of this screw causes the nut which is attached to the prism to travel, since it cannot rotate.

The coincidence adjusting slider, which is shown alongside the deflecting head in Fig. 36, is used when the coincidence or scale adjustment of the instrument has to be altered. That is either when it is first calibrated, or later when for any reason it is not indicating correctly. As will be seen from Fig. 36, the slider is connected to a coincidence coupling rod which is normally retained in the position shown by a spiral spring. The effect of moving the slider and compressing this spring is to slip the gear wheel which drives the deflecting prism screw endways and out of gear. The gear wheel which drives the scale drum also moves endways but, as shown in the figure, its width is such that this action does not put it out of gear with the teeth of the scale drum. The effect of the arrangement is that when the slider is moved endwise the deflecting head can only drive the scale drum and not the deflecting prism. The scale may thus be set to indicate the known range after the images of some object at a known distance have been brought to coincidence in the field of view.

The other operating or adjusting devices operated from the neighbourhood of the cover ring do not require to be dealt with in any great detail. The astigmatiser slide and operating gear are clearly shown in Fig. 37. It will be remembered from our earlier description that the astigmatising arrangement consists of two astigmatic lenses which are moved into the paths of the two beams of light at their entrance to the central system of eyepiece prisms. They are used to draw out the image of a point of light or a small object into a vertical line suitable for coincidence working. The two lenses are carried on pivoted levers and are swung into the beams of light when required by a cam plate actuated from the astigmatiser slider. The halving adjustment tilts a piece of parallel glass in the right-hand beam as already described. The arrangement consists of a halving head, or milled roller, like the deflecting head. The halving head is in the form of a nut and carries a central screwed shaft which acts as a pusher to swing the halving glass which is mounted in a holder. The holder is kept against the pusher by a spiral spring. The arrangement is clearly shown in Fig. 37. To render the scale visible at night a small electric lamp is fitted on the instrument. The lamp holder is shown in detail in Fig. 43. When in place on the rangefinder it is fixed near the scale-illuminating window, as shown in Fig. 34. The lamp may be operated by a low voltage battery or by current from a transformer circuit. A push for switching the lamp into circuit is fixed on the top of the instrument in such a position that it can be operated by the thumb of the hand which is working the deflecting head.

As has already more than once been referred to, and as is clearly shown in Figs. 36 and 37, the whole of the important parts of the rangefinder, with the exception of the end reflectors, are carried on the frame tube. In order to protect this tube from distortion, due to the application of forces to the outer tube, it is supported in a special manner. The left-hand support is a gimbal ring which can be seen from Figs. 36 and 37, detailed views of the ring being given in Figs. 41 and 42. It will be clear that this mounting prevents end, sideways and rotational movement of the frame tube, but does not constrain it in any other way. The right-hand support is a spherical bearing which prevents the

frame tube from moving sideways, but does not constrain it endwise or rotationally. The frame tube itself is a continuous brass tube carrying at its centre a casting for the support of the eyepiece prism box, as shown in Fig. 38. The objectives are mounted in holders which lie inside the frame tube at each end. The objectives themselves are corrected for aberrations and are achromatic, being made of two suitable qualities of optical glass ground to the required curvature and cemented together with Canada balsam. When mounted in their holders they are protected around the sides with soft packing and around the top and bottom edges with cork. The holders are provided with screwed caps which enable the objectives to be gently bound into place. To enable the objectives to be set at the correct focal distance, the holders can be moved within the frame tube. They are finally fixed in position by means of screws. The arrangement of the objectives and their holders can be seen in Figs. 36 and 37.

The arrangement of the central prism system is shown in Figs. 50 to 52, on page 539. There are three prisms of optical glass, placed together as shown in these figures and cemented with Canada balsam. The course of the rays of light from the objectives to the observer are indicated by full and broken lines. The lines with arrow heads represent rays of light coming from the left-hand objective. After refraction at the separating prism these rays form the image seen in the lower half of the field of the right eyepiece. The rays from the right-hand objective, represented by the broken lines, after being refracted by the separating prism form the image seen in the upper half of the field of view. The objectives invert the images transmitted to the prisms, but a study of the path taken by the rays will show that the prisms re-invert them, so that an erect image is seen by the observer in the field of the right eyepiece. It will be seen from the figures that the separating prism has two faces inclined to one another so as to include a very obtuse angle. This side of the separating prism is on the opposite side from the eye of the observer. It is the intersection of these two faces that forms the separating line across the field of view, and the arrangement is such that a very fine line is obtained. The rays of light from the left-hand end of the rangefinder fall at an angle upon the lower face of the separating prism and are refracted out towards the eye. Any rays that may fall upon the upper face are refracted outwards at a different angle and do not enter the eyepiece. In the same way rays of light from the right-hand end of the rangefinder are refracted by the upper face of the separator, the rays falling on the lower part being refracted at a different angle so as not to enter the eyepiece. It will be seen from this that the separating prism effects an absolute separation of the rays of light from the two telescopic systems.

Turning now to the mountings which are used with this type of rangefinder, we may first refer to Figs. 44 and 45, on Plate XXXI, which show a common form of naval mounting. The same mounting is also shown in Figs. 53 and 54, on page 539. It is made throughout of non-magnetic materials to permit it being placed in the neighbourhood of a compass if desired. The instrument is carried in bearings, resting on the two bearing rings which form part of the outer tube and which have already been referred to. The rangefinder is controlled in altitude by means of the handle which is attached close to the left-hand bearing ring. This handle is held by the finger and thumb of the observer's left hand and the motions of the instrument are easily kept under control. This is facilitated by a hand-steadying quadrant attached at the left hand side of the rotating bracket which forms the top of the mounting. This quadrant is clearly shown in Figs. 44 and 45. The rangefinder is adjusted in azimuth by rotating the bracket on top of the fixed pedestal. As is shown in Fig. 44, there is a hand wheel situated at the top of the pedestal and inside the bracket. This operates a lifting screw by means of which the position of the eyepieces may be adjusted to suit the individual height of the observer.

Attached to the rotating bracket there is a body rest which the observer leans against when using the instrument. By its help he is greatly assisted in controlling the azimuthal motion. The body rest is hinged, and can be locked by a pin in various positions to suit different observers. When not in use it can be folded back within the forks of the rotating bracket. It is found in practice that it is easier to keep the rangefinder steadily on an object than it is to do the same thing with an ordinary telescope, and that ranges can be correctly taken in such seas as would render practice with large guns impossible. Normally the mounting is fixed to the deck with screwed holding-down bolts, hard rubber washers being inserted between the deck and the pedestal to reduce vibration. This arrangement is shown in Figs. 44 and 45. An alternative method of fixing the mounting to the deck is shown in Figs. 46 and 47. With this construction the mounting is secured to rails and may be traversed. The details are clearly shown in the figures, from which it will be seen that the mounting runs on rollers working on flat rails, and that it is locked in position by clips operated by hand wheels and sliding on a centre bulb rail. The path of the mounting may be curved, and to allow for this the boxes which hold the rollers may be swivelled and the rollers so set to the correct angle. The roller boxes are locked in position by pinching pins after setting. A simple form of mounting used for fortress work is shown in Figs. 48 and 49. The figures show the arrangement well, and it is not necessary to refer to them in any detail. It will be seen that a seat is provided and a worm gear, operated by a hand wheel, for rotating the instrument in azimuth.

(To be continued.)

THE BRITISH ASSOCIATION.

(Continued from page 521.)

We now turn to the transactions of the Chemical Section.

SECTION B.—CHEMISTRY.

The Chemical Section can look back upon a most successful meeting. This is all the more gratifying since chemical industry had no home at all in the Bournemouth district before the establishment of the Naval Cordite Works at Holton Heath, to which the section was able to pay a visit. The 18 papers and reports discussed on four mornings and two afternoons were so well grouped, that members were little tempted to stray away into other Sections. That temptation is particularly strong for chemists perhaps, because their science is highly specialised on the one side, and on the other hand most intimately interlinked, in various grades of relationship, with almost all other branches of science. On the first two mornings and on Tuesday afternoon the influence of the war upon chemistry and chemical warfare came up for discussion in papers on explosives and gas, on geochemistry, refractories and glass, and on metallurgy. The further discussions of the third morning of certain equilibria and reactions and on bacteriology again had a very direct bearing on war problems. Friday morning was devoted to the fuel problem, and the proceedings concluded on Friday afternoon with papers on chemical reactivity and valency. The sectional officers were: President, Professor P. Phillips Bedson, D.Sc., of Armstrong College, Newcastle-upon-Tyne; Vice-Presidents: Professors E. E. C. Baly, F.R.S., of Liverpool, and G. G. Henderson, F.R.S., of Glasgow; Secretaries: Dr. A. Holt, of Liverpool (Recorder); Professor Cecil H. Desch, D.Sc., of Glasgow, Professor R. Robinson, D.Sc., of Liverpool, and Mr. H. Painter, B.Sc., of Bournemouth.

Presidential Address.

Professor Bedson did not, in his address, dwell upon coal and explosive combustion, the lines of research in connection with which our readers will remember his name. He had selected two subjects, the fiftieth anniversary of the enunciation of the Periodic Law and the development of that law, and the welfare of chemistry in this country. But he first referred to the losses chemistry had suffered since the last British Association meeting by the passing of Crookes and Rayleigh and of two great chemists, W. von Bacyer and Emil Fischer, from the teaching of whom many British chemists, among them some of the most distinguished, had received guidance and inspiration.

Suggestions of periodicities in the chemical elements go back more than fifty years, of course. Without wishing to enter on the vexed question as to whom should be assigned the credit of the discovery of the periodic law,* Professor Bedson stated that fifty years ago Mendeleieff had communicated to the Russian Chemical Society a memoir which had exercised a profound influence on chemical philosophy. That memoir on the principle of periodicity, the recurrence of similar properties at regular intervals with increase in the atomic weights, had showed the possibility of utilising the atomic weights as basis for the classification of the elements, the necessity for the revision of the atomic weights, and the need of search for missing elements. The clearest demonstration of the association between atomic weights and physical was undoubtedly exhibited by Lothar Meyer's curve of atomic weights and atomic volumes, on which the members of the natural families occupied corresponding positions. Briefly reviewing the development of the theory, Professor Bedson mentioned in the first instance Dewar's discovery that, at 50 deg. absolute, the specific heats of all the elements were a periodic function of the atomic weight, thus supplementing the old law of Dulong and Petit which referred only to solids at ordinary temperature. Most of the apparently anomalous positions of some elements on the old tables had been corrected by the revision of the atomic weights, but tellurium still refused to fall into line, and the proper grouping of the rare earths remained controversial even after Werner's classification of 1905. The new inert or non-valent gases, argon in the first instance, would not fit into the table and its VII groups at all, and had been accommodated in a zero group. It was interesting in this connection that Mendeleieff himself had thought of a zero group to include an element lighter than hydrogen and the ether of the physicists. From helium and its manufacture on a big scale Dr. Bedson passed on to radioactivity and the complexity of the atom and the transmutation possibilities; to the early speculations of T. Carnelly, one of his fellow students and ardent adherents of Mendeleieff, on the compound nature of the atom; to Crookes' genesis of the elements, J. J. Thomson's electrons, X-rays, to the disintegration of the radio-elements and to isotopes; to Moseley's atomic numbers, and to the need of full explanations of variable valency and selective valency.

The second part of Professor Bedson's address was critical, like that of Professor Gray. He spoke of the realisation on the part of the public and Government of the importance of chemical industry to the national well-being as one of the revelations and surprises of the past five years. The "aniline phantasm" had been recognised as a "key industry"; but special knowledge was still a "dangerous thing" excluding its possessor from a seat on the directorate of British Dyes, Limited. The Foreword to the "Reports on Costs and Efficiencies of H.M. Factories," issued by the Ministry of Munitions, seemed to express surprise at the lack of trained technical men, particularly chemical engineers, though it also said that it was amazing that manufacturers could expect improvements in chemical processes when their chemists were kept in ignorance of the vital facts of the plant cost and its efficiencies. We were to believe, Dr. Bedson continued, that all this was changed, and that the magnificent achievements of British chemists in the war had educated the people and the Government as well. But a feeling akin to despondency, if nothing worse, was pardonable, when a review on "The Value of Scientific Research" (published three years ago) had characterised the production of new colours as a succession of happy thoughts and stated that by "an accident the secret of synthetic indigo had been unlocked." He had himself protested at the time that the unravelling of that constitution had occupied Baeyer and his pupils for thirteen years.

* Professor Bedson mentioned John A. R. Newlands, Mendeleieff and Lothar Meyer.

Yet he would not conclude with a despondent note in view of the many activities operating for the promotion of scientific research.

Chemistry and the War.

Sir William J. Pope, F.R.S., of Cambridge, approached his subject, "Chemistry and the War," from the national and political standpoints. The outbreak of the war, he said, had been the signal for the conversion of the great German colour-making factories into manufactories of explosives. During the war the British demands for trinitrotoluene and picric acid rose to 1,000 tons each per week, and of ammonium nitrate to 3,000 tons; but facilities for these manufactures had practically been non-existent, and 80 per cent. of the toluene for T.N.T. had in the first year been derived from Borneo petroleum. The quinine had come from Java, the import into Europe being under German control; many indispensable pharmaceutical products and fine photographic chemicals had almost exclusively been made in Germany, where the manufacture of nitric acid from the atmosphere had been brought to perfection. Over here explosive factories had had to be put up hurriedly for war purposes alone, and the great installation at Gretna was now practically a scrap heap, whilst the German chemical industries emerged from the war in a stronger position. It might be insisted upon that Germany had never commanded any monopoly of scientific talent, not even in the discovery of materials used in chemical warfare. Thus phosgene was discovered by Davy in 1812, chloropicrin by Stenhouse in 1848; both these substances had been produced in the German dye industry, but here methods had had to be worked out for their technical manufacture during the war. The most powerful agent in gas warfare, mustard gas, had been discovered by F. Guthrie in 1860; British chemists had produced a superior mustard gas by a much simpler process than the very complicated German method, but it had taken a year to develop that method. [The chemists were Sir W. Pope himself and Mr. C. S. Gibson; the gas is β β-dichlordiethyl sulphide.] Great Britain might well be proud of her chemical record, but a great danger threatened her from the intensive utilisation of the magnificent producing organisation of Germany and German propagation, in spite of the highly-favoured position of the British Empire as to all raw materials.

Gas Warfare.

In his paper on "Gas Warfare" Brigadier-General H. Hartley spoke from the military rather than from the chemical standpoint. The war had often looked a chemist's war, he said, and failure of the chemists on either side might have led to speedy ending. The object of his paper was to sketch out the development of gas warfare. Gas attacks had been made by closed cylinders and by projectiles. The first German gas attack of 1915 had found our troops totally unprotected, but the enemy had missed his opportunity by the use of gas in low concentration and quantity. A special brigade consisting entirely of specially-enlisted British chemists had then been formed, and altogether 768 British gas operations had been carried out and 5,700 tons of gas had been liberated; evidence of the effects had soon been found in captured documents. The cylinder gas had been mainly phosgene and a phosgene-chlorine mixture. Shells were a more flexible weapon, and concentration was in their case a vital factor. The development of German gas warfare had been very rapid; gases of the lachrymatory types had predominated. Among the German gases were: xylilbromide, a brominated ketone of boiling-point above 200 deg. C.; and chlormethyl chlorformate (105 deg.), soon replaced by the trichloro compound which was used till the end of the war; chloropicrin (112 deg.); since July, 1917, dichlormethyl sulphide (217 deg.), very effective because persistent, affecting eyes and lungs, blistering the skin and giving little smoke. The diphenyl arsine, a solid (melting-point 46 deg.) which was mixed with high explosives to scatter as a dust, had proved almost a failure, and was replaced in 1918 by a cyanogen derivative (melting-point 23 deg.). The dichlormethyl arsine of 1917 caused also temporary loss of feeling in the limbs. By 1918 the Germans had made use of shells of two kinds, the one containing liquids for shelling territory not intended to be occupied, the other containing highly-volatile liquids to be used immediately before an attack.

The British troops had used lachrymatory gases first on the Somme in 1916, and had later in the year fired Livens projectiles in enormous numbers; a novel trench mortar had been charged with half its own weight of gas, and this weapon had, in 1917, developed into one of the most deadly for trench warfare. In the break through the Hindenburg line in September, 1918, the enormous quantities of mustard gas had been of great importance. The British gas attacks had been effective even in high wind, the wind generally being favourable to them. The effect was partly due to the gas terror. Respirators and masks to be worn for hours made exertion impossible; dug-outs were not safe against gas, which disabled men for hours and days; the withdrawal of batteries, the supply of ammunition, and the relief of troops were severely interfered with by gas. Gas warfare had been condemned as inhumane, and the early gas attacks had terribly increased the mental and physical suffering of the soldiers. Accepting war as a possibility, however, that weapon was most humane which led to a decision with the smallest amount of suffering and death. From that standpoint, gas compared favourably with other weapons during the period that the troops were fully equipped for gas defence and offence. Not only was the death rate by gas much lower than that of other forms of casualties, but a much smaller percentage of men suffered permanent disability. There was no comparison between the permanent damage done by gas and by guns and shells, and during the later stage of the war results were obtained at much smaller permanent suffering by gas than by other means. The pathetic appeal of a well-known picture of the victims of the first mustard gas attack had strongly influenced the popular judgment; but 75 per cent. of those blinded men had been fit for duty again within three months, and high explosives would have made their fate infinitely worse. General Hartley did not give particulars with respect to the gases. But he praised the work done at the universities, often at considerable risks, and he briefly mentioned the various types of respirators introduced since 1915. In April, 1915, there had only been one liquid-chlorine plant in the country, and the total production of chlorine had amounted to 860 tons; by 1917 that figure had risen to 18,500 tons.

High Explosives.

In introducing his very instructive lecture on "High Explosives" Lieutenant-Colonel C. D. Crozier, Director of the Inspection Department of High Explosives, remarked that the devastation of the war had mainly been brought about by high explosives (H.E.). Though lyddite shells had been used in South Africa and in other wars, and though the heavy artillery of the Navy had used H.E., the general equipment had only been with shrapnel. A shrapnel bursting overhead sent a shower of bullets through a pipe when the time fuse reached the powder in a cup; to be effective the bullets should strike with a velocity of 400 ft. per second; the shell generally came down whole. An H.E. shell was a simpler affair and was blown to pieces when it detonated. Before this war picric acid had practically been the only H.E. in use. Discovered by Haussmann in 1788, picric acid had not been put into shells before 1893, and the total production of this country had, in the first six months of 1914, amounted to 331 tons, whilst in 1917 it had risen to 1,000 tons per week; then T.N.T. and ammonium nitrate had forged ahead. To prepare the picric, phenol was heated with sulphuric acid, and the sulphuric acid obtained then slowly mixed in earthenware pots, with nitric acid; that took 8 hours and more, one-third of the acid was lost in vicious fumes and 100 lb. of carbolic acid rarely yielded more than 180 lb. of picric, against the theoretical 242 lb. With the aid of many slides Colonel Crozier explained the various improvements of this old method, the replacement of the glass siphons by pipe lines, the drying of the picric, which is finally packed in 50 lb. cotton bags, with the aid of steam coils, &c.; yet for some reason explosions of picric had been more numerous during the war than before.

The phenol supply from coal tar proving insufficient, phenol had been made synthetically. Then Major L. B. Holliday had, at his own risk, started making picric from the dichlornitrobenzol of the United Alkali Company, and the Government had duplicated his plant, and had also directly nitrated synthetic phenol at a much quicker rate and in smaller sheds. Another excellent process, remarkable for its labour-saving, had been worked out by Mr. Newton Brooke, a stoneware manufacturer of Halifax, in the Highcliffe works. He nitrated, not in pots, but in tanks, 160 ft. long, producing up to 30 tons of picric continuously per week; the sulphuric acid first made entered at one end, and the nitric acid was introduced in jets through aluminium pipes; the picric was delivered at the vacuum filters, the nitration took place at 102 deg. C. (against 115 deg.), and the yield rose to 194 lb., the picric produced having a melting-point of 121·4 (pure picric 121·6) deg. C.; the fumes were condensed, and there was no acid effluent.

Turning to trinitrotoluene (T.N.T., trotyl, trinol or tolite), Colonel Crozier said that this explosive had, over here, only been made by Leitch and Co. before the war. The first superior method had been worked out in the Woolwich Research Department by Sir R. Robertson. Later many private firms had taken the manufacture up, and the Government started the Queensferry (Chester) works (first for cordite only) in September, 1915, which were producing by March, 1916. The staff there rose to 7,325 (3,232 women), the average monthly wages to 73,000*l.*, altogether 55,000 tons of T.N.T. were delivered, and the price was brought down from 10*s.* to 1*s.* per lb. Oleum was made from pyrites, the nitration was effected by a two-stage process [we have explained the general features on other occasions]. Gaillard towers were used, the T.N.T. was "pelleted" by being run into water, and the pellets shot into wagons; the symmetrical T.N.T. (one of the six isomers) was dried in Clayton driers and, still liquid, was run from these into troughs and scraped off in flakes from cooled hollow cylinders. Three grades of T.N.T. were supplied, pure, medium and impure. Messrs. Chance and Hunt used another continuous process. At the Gretna works, which were due to the genius of Mr. K. B. Quinan (an American, formerly of the Cape Explosive Company, South Africa), propellants, not high explosives, were made. As regards tetryl, trinitrophenylnitramine, a detonator, of which a shell contained only a few drams, Colonel Crozier could only say that it was made by nitration of dimethyl aniline.

Ammonium nitrate, he continued, itself harmless, became a powerful explosive when mixed with T.N.T.; this amatol (sold before the war as roburite and dreadnought powder) was used in trench mortars, grenades, land mines, &c. In all 378,395 tons of ammonium nitrate had been produced, by various processes. First from Norwegian calcium nitrate and ammonium carbonate; then at Lostock from sodium nitrate and ammonium carbonate by an exceedingly delicate equilibrium process. Then Messrs. Brunner, Mond and Co. (who had first manufactured synthetic phenol and ammonium nitrate and purified T.N.T.) took up the utilisation of their calcium chloride waste as proposed by the Ammonia-Soda Company, of Pumbley, and subsequently succeeded, in their Sandbach works, in the double decomposition of ammonium sulphate and sodium nitrate; this latter process was also adopted by the United States at Perrivale in Maryland. Among other explosives Colonel Crozier mentioned ammonium perchlorate, made by the United Alkali Company from sodium perchlorate (from common salt by electrolysis) which was converted into ammonium perchlorate.

Passing finally to the Inspection Department, Colonel Crozier said that this department, formerly under the Ordnance Department, was liable to much criticism, as it was held responsible for failures and was blamed for holding up stores when it did not pass goods. The staff of the department had risen from 25 officers and 200 or 300 men

finally to 60,000 in the war, though his own staff had not exceeded 30 officers. The work could not have been carried out if, in 1915, the Universities of Birmingham, Leeds, Liverpool, Manchester and Edinburgh had not offered their help. The point was to clear the works as soon as possible, and their practice had been to take samples, put the bulk on rails, and test the samples before the bulk arrived at its destination. The whole inspection cost only a few pence per 100*l.* worth of materials, and the inspection had saved the country thousands of pounds—and not only money, we might add.

Equilibrium in Ammonium-Nitrate Systems.

The paper by Dr. T. M. Lowry and Dr. E. P. Perman on "Equilibriums in the System Ammonium Nitrate-Ammonium Chloride—Sodium Nitrate—Sodium Chloride," has an important bearing on ammonium-nitrate explosives, and Colonel Crozier had referred to the researches conducted by Dr. Lowry and his collaborators in Guy's Hospital. The point was, as Dr. Lowry explained, that some explosives which are pressed hot into shells, consisted largely of ammonium nitrate melting, they had found, at 169·6 deg. C. when pure. The presence of impurities of the salts mentioned above lowered the melting-point considerably, and the mixing of the nitrate with T.N.T. (melting-point 81·5 deg.) further depressed the melting-point of the filling so that trouble arose. Hence these equilibrium studies of Dr. Perman. The nature of the impurity depended chiefly on the method of manufacture, Dr. Perman said, and chlorides or sulphates might predominate. The reversible reactions between the salts would be of the type $NH_4NO_3 + NaCl \rightleftarrows NH_4Cl + NaNO_3$, and they had observed the crystallising points and studied the eutectics of a great number of mixtures of the salts in various proportions. Ammonium nitrate and chloride had a eutectic point at 142 deg., the eutectic containing 12·1 per cent. of the latter; ammonium and sodium nitrates had a eutectic point at 121 deg., with 20·5 per cent. of the latter salt. The lowest eutectic point observed in the presence of chlorides was 112 deg., the eutectic being the ternary compound (ammonium nitrate, sodium nitrate, ammonium chloride). and that point of 112 deg. had been reached by various ways. The addition of sulphates lowered the melting-point of the ammonium nitrate to 121 deg., while the addition of sulphate to the ternary eutectic just mentioned did not further depress the melting-point, but raised it; these reactions required further investigation, however. The results of these equilibrium studies were plotted in several ways, and a discussion arose between Professor Desch and Dr. Lowry as to the advantages of those equilibrium-diagrams. The ammonium nitrate, it was mentioned, is polymorphous.

An Ammunition Chemist in the Field.

Major E. R. Thomas, M.A., M.Sc., presented, under the title of this note, a suggestive communication on one of the various duties of an ammunition officer in the field, the disposal of dangerous and unserviceable ammunition. Stores such as "ground flares" (consisting of shellac and nitrates) and "smoke-candles" (pitch and potassium nitrate), which depended for their efficiency on the dryness of their priming composition, were particularly liable to deterioration on exposure, and large quantities of these products had on examination been found to be unserviceable, he stated. He had been horrified to find that such stores were being burnt or dumped in the English Channel with a considerable expenditure of time and labour. Although he had been advised to conceal his knowledge of chemistry—advice not without its point—he had been able to elaborate a simple method for the recovery of the pitch and potassium nitrate, and had, with the aid of a band of Chinese coolies, produced over a ton of pitch and nearly a ton of the nitrate daily, by crude methods. The extraction had been effected in Soyer stoves, and the crystallisation in unserviceable cartridge cylinders; the stirrer was part of a broken ammunition box, and the fuel waste wood from the same source. Allowing for all expenses the work had resulted in a profit of at least 20*l.* per day, while the expense involved in the destruction of the stores had been saved. The pitch was mixed with sand and utilised as a substitute for timber for flooring purposes. Some of the work had been carried out at two convalescent camps where the labour cost was nil. In both these places very large "physical training huts" were completely floored with material made from the recovered pitch, while the recovered potassium nitrate was stored and ultimately returned to England. The success of these operations had led to their authorisation and extension to many classes of unserviceable ammunition previously dumped in the Channel.

Geochemistry and the War

The exact scope of geochemistry, Professor P. G. H. Boswell, of Liverpool, remarked in his paper on "Some Geochemical Problems dealt with During the War," was debatable. The scope had been extended in the course of the pleas recently made for the establishment of a Geochemical Institute in this country, so as to include not only the chemical investigation of the problems of the changes in rocks and the phenomena attending them, but also chemical research for the industrial utilisation of rocks and minerals. Professor Boswell discussed the extended investigations of British materials, the replacement of rocks and minerals hitherto imported, and the relief the researches had brought to the country in general and to transport and shipping. He referred to the fixation of nitrogen, to potash-bearing minerals, potash from blast furnaces and cement kilns; to the coprolite-bearing deposits of the Cambridge green sand, opened up to extract their phosphates; to the ore industries and to refractory materials, giving ample references to special reports by the Geological Survey, Government Departments and Proceedings of Societies; we missed references to the work of the National Physical Laboratory, however. Silica bricks made by burning gannister with 1 per cent. of milk of lime could appreciably be improved, he said, by burning for longer periods at higher temperatures than had previously been the practice (1,300 deg. C.). In the potteries British felspar, flint and sand had been substituted for foreign materials; home dolomites had been drawn upon with noteworthy success in the place of Austrian and Greek magnesite for the basic linings of steel furnaces; the cinder lag and magdalite, &c., of American cement kilns were produced from dolomite, silica, iron oxide, &c. The sand from Leighton Buzzard, Lynn, Hutton Ambo (Yorkshire) and many other localities had been found quite suitable for lining acid open-hearth steel furnaces; that sand should contain certain impurities of alumina, lime, magnesia, &c., sufficient to be of such a size as just to "frit" and to bind together on the sides when the furnace bottom was being repaired, but the sand should be free of alkalis and contain 98 per cent. or 99 per cent. of silica. In sand for glassware the same silica percentage and absence of iron was desirable; the iron should not exceed 0·08 per cent. of Fe_2O_3 for lighting glass and pressed ware, and 0·02 per cent. for optical glass; alkalis and alkaline earths were not harmful, and the presence of alumina was an advantage for glasses where toughness and absence from devitrification were required. The sands for founding metals and alloys, especially steel, offered perhaps the most difficult problem. Such sand should contain a maximum of silica and a minimum of alkaline constituents; it should strip freely from the castings, for which purpose a moderate quantity of hydrated ferric oxide was serviceable; to make the sand "bond" well against the molten metal, as well as to take up water, without becoming wet, in the first instance and after dehydration by the hot metal, the sand should contain clayey and micaceous material as well as hydrated ferric oxide in the colloidal condition; compounds of cerium and zirconium were only needed in very small quantities in the synthetic preparation of moulding sands. As regards the texture of moulding sands coarse and medium grades (grain diameter exceeding 0·25 mm.) should predominate, fine sands and sill (down to 0·01 mm.) should be kept very low, whilst the relatively high proportion of clay should be of very fine grade (below 0·01 mm.); the chemical analyses of these various grades by elutriation had given valuable results. In his concluding remarks Professor Boswell referred to the dangers to which the cheapness and easy import by ship from the Continent, Belgium, &c., exposed these British key industries. If restrictions could not be put on foreign imports, recourse should be had to the revision of railway freights and to the rapid development of internal water transport.

Glass Manufacture at the End of the War.

Commenting upon the difficulties of materials and labour, and of emergency plants worked beyond their economic limits, Dr. Morris W. Travers, F.R.S., said in his paper on "Glass Manufacture at the End of the War," which was read by Dr. A. Holt, that we might lose the opportunity of consolidating our position while continuing to celebrate our victories, and that the restrictions on imports and other schemes for safeguarding the glass industry could only be effective if the industry strained every effort. Success did not depend upon trade secrets. The way had been paved under the Government scheme for a Glass Research Association. Much of the research had to be carried out in the works, and demanded the keeping of exact records. Lamp workers at the table blow-pipe had reason to be dissatisfied with their material. Those glasses must be soft; they "plained" (freed themselves of seeds and bubbles) only when strongly heated, but most of the furnaces could not be worked at sufficiently high temperatures. The best resistance lighting-ware (formerly Austrian) contained much borax, now expensive. The substitution of soda for potash in bulb glass had not proved satisfactory. With respect to raw materials, Swedish feldspar, containing 13 per cent. of potash and hardly any iron, had still been obtainable, flour-ground, in London at less than 3*l.* per ton by 1915. At present lumps of Cornish feldspar, with less than 10 per cent. of potash and a considerable amount of iron, cost over 7*l.* per ton. Very crude methods were still employed in the handling, grinding and mixing of the cullet and batch, as glass makers disliked machinery. In the old days the pots were filled once a week, on Friday, to be ready by Monday; gas-firing allowed of filling two or three times a week, but the furnaces only lasted two years and the pots gave trouble. With the recuperative gas-firing the refractory material failed frequently. The position of the tank furnaces was more satisfactory, but there also the refractories needed improvement. As regards mould-blown bulbs and other ware the trained lads had not shown the skill of the experienced men, and the progress in mechanical methods had been restricted to the introduction by two British firms of American (Empire and Westlake) machines. Progress in the manufacture of jars, bottles, &c., had rather been starved by the war, and as experimenting in this field was very costly, there was a tendency among our manufacturers for purchasing the rights of using American machinery. The output of glass tubing had enormously increased, and statistics as to the different successful methods would be very interesting. The general design of glasshouses also needed further attention; there was much unnecessary walking about and much breakage in conveyance of the goods from one department to another, and Dr. Travers, after visiting a considerable number of British glass works, rather wondered whether glass works were usually planned in this country, or whether they grew while nobody was looking on.

Passing to annealing, Dr. Travers commended the work done by Mr. Twyman and the staff of Messrs. Adam Hilger, whose instrument for testing goods after annealing had found wide use. In resistance glass (breakers and flask) and heavy hollow-ware (dessicators, aspirators, &c.), the country was now self-supporting; as to glass for high pressure and fireproof glass for chimneys, and certain globes and bulbs, the manufacture was not yet able to cope with the demand. With respect to optical glass in particular, and the stirring and the reduction of wastage between the founding and the formation of the blocks, much remained to be investigated. The replacement of hand-made glass by machine-made goods might be unavoidable; yet American mechanical reproductions of English cut-glass, though

very wonderful, absolutely lacked the craftsman's touch. The old-fashioned round furnace was a fuel-wasting machine, however, and should be prohibited in the national interest.

During the discussion Sir Robert Hadfield regretted that we had still to go to Germany and Austria for the best lenses; he had been unable to obtain here lenses equal to those of foreign make in use in his works.

(To be continued.)

THE CONSTRUCTION OF THE UNITED STATES TORPEDO-BOAT DESTROYER "WARD."

DURING the later years of the war, and particularly after the entry of the United States, reports appeared in the Press, many of a misleading nature, concerning riveting and other records set up at various shipyards in Great Britain and America. The value of such records was discussed with some acrimony. There is no doubt that after a shipowner has placed an order the principal record that interests him is the time that elapses before the ship is delivered for service in a thoroughly efficient condition. If twelve months elapse before his vessel is laid down it is poor consolation to point out that the hull was built in record time on the slip. Again, a warship is generally of less ultimate value to a navy if its construction has been rushed at the expense of workmanship, and as a result the vessel spends six weeks a year more at a dockyard undergoing repairs than a sister ship, that took a month longer to build because of the greater care exercised and the more particular attention paid to vital tests. In regard to riveting, the U.S. Emergency Fleet Corporation compiled statistics of the number of rivets driven at various yards, and the reduction that for several days followed a day of phenomenal output was a noticeable feature. The man in the street received a glowing account of the record, but heard nothing of the slump that followed.

On the whole, however, the general result of this spirit of competition was good. Shipyard managers and workers were put on their mettle and braced themselves to make further exertions.

When, in September, 1918, the Secretary of the United States Navy announced that at the Mare Island Navy Yard, California, the Destroyer Ward had been put into commission seventy days after the keel was laid, it appeared at first sight as though destroyer builders in this country would have to look to their laurels. From the details of this performance we now publish it will be seen that British yards need not fear comparison with this record, excellent as it was. These particulars also indicate the effect on shipbuilding practice of quantity production of ships, especially in the United States, the decreasing relative importance of work on the slip under modern conditions, and the smaller number of slips consequently necessary for a given output.

On July 20, 1917, the officers of the Mare Island Navy Yard were directed to build the hulls and machinery of six destroyers of which U.S.S. Ward was one.

The following are the particulars of these vessels:

Dimensions...Length between perpendiculars, 310 ft.
Breadth on load water line, 30 ft. 10¼ in.
Mean draught, 9 ft.
Corresponding displacement, 1,154 tons.
Armament...Four 4-in. guns.
Two 3-in. H. A. guns.
Four triple 21-in. torpedo tubes.
Depth charges.
Machinery...Parsons geared turbines, 26,000 s.h.p.
Speed ... ...35 knots.

Prior to 1916 this Navy Yard had had no experience in the construction of torpedo boat destroyers. Two were laid down there in 1916 and two in 1917. All the more credit is, therefore, due to those who had the courage to aspire to record breaking and the ability to achieve their object. Mr. Daniels, too, was able to use this performance more effectively to spur on more experienced destroyer builders who had failed to fulfil their promises.

The preliminary work was carefully organised, as it was necessary that these six destroyers should occupy the slips for a minimum time. Special attention was paid to the mould loft work. Lifting templates to the ship, and drilling at the ship, were eliminated. Complete moulds were made for all members, those for the shell plates showed the various holes for side-lights, condenser inlets and outlets, and similar openings.

On account of the great demand for shipbuilding steel, particularly the special quality used in the construction of destroyers, material could not be obtained as rapidly as was desired. Delivery commenced late in November, 1917, the bulk of the steel did not arrive till late in January and much of the later material not until the latter part of February, 1918.

FIG. 1. LAYING THE KEEL, MAY 15, 1918.

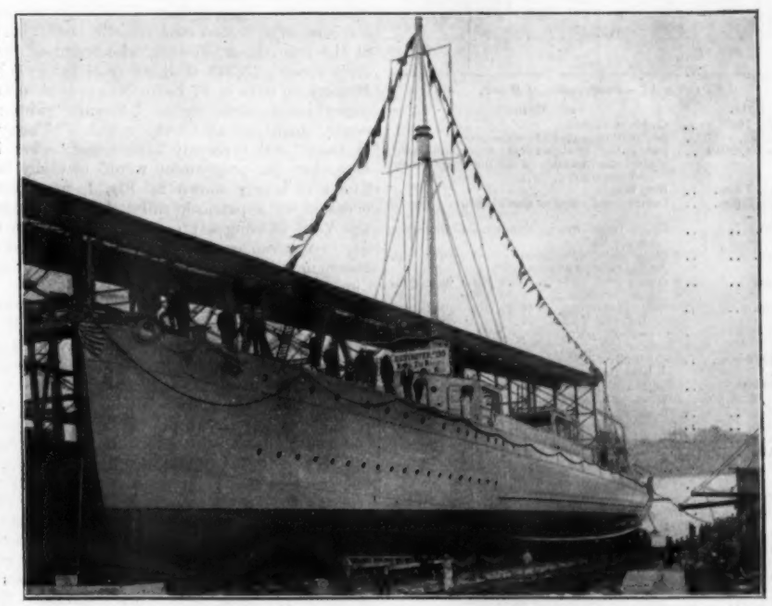


FIG. 2. READY FOR THE LAUNCH, JUNE 1, 1918.

To expedite construction certain departures from usual practice were made, more particularly in testing watertight compartments. The following is the usual United States practice for destroyers:—

To test by water for strength and tightness at least one engine room and one boiler room, at least one compartment representing each kind of structural construction, and all hold compartments including reserve feed, fresh water, and peak tanks, to a head of 14 ft. above the bottom of the keel. To test oil fuel tanks with water to a head of 22 ft. above the bottom of the keel, or with air at a pressure equivalent to the specified test water pressure at the mid-height of the compartment, but in no case at less air pressure than 5 lb. per square inch. To test, by air, hold compartments and tanks to ensure tightness of fittings, this completion air test being made at a pressure equal to the water test pressure of the deck bounding the top of the compartment, but in no case at less than 2½ lb. per square inch. Finally to test fuel oil tanks by filling with oil to a head equivalent to the water test head maintained for at least 24 hours. The water tests of the compartments adjacent to the outside plating have to be made before launching.

In the case of the Ward the bulkheads in machinery spaces were tested by a water jet from a hose, the water pressure test for strength was waived as these bulkheads were similar to those of the destroyer Fairfax, built at the same yard to the same scantlings and satisfactorily tested under water pressure. Prior to launching, three oil fuel tanks and the reserve feed tank were given a six-hours water test with the heads enumerated above.

Half the remaining watertight compartments were tested by water-pressure for six hours to the specified head when the vessel was in dry dock, the remainder when the vessel was afloat. The completion air-tests of oil fuel tanks were carried out, but the tanks were not filled with fuel oil and tested until after commissioning and just before the departure of the vessel on trials. The reports received from the ship after a few months duty did not indicate any reduction of watertight integrity due to this reduction in tests.

In actual construction the following departures were made from previous practice. Lightening holes up to 7 in. in diameter were punched; larger lightening holes of elongated form, were punched at the ends and the connecting straight edges were sheared; only the butts of plates were planed, the edges were sheared except those of the stringers and sheer strakes; where practicable, as in the case of small size plates for floors, webs, and stringers, one plate was laid off and fabricated, and then bolted to the five remaining similar plates for the five sister vessels and used as a template jig.

Table I.—*Material Installed and Men Employed on the Slip.*

Day.	Material Installed.	Men Employed.						
		Riveters.	Ship-wrights.	Helpers.	Holders-on.	Rivet Heaters.	Boys.	Appren-tices.
	Tons.							
1 ..	67·56	—	3	28	—	—	2	3
2 ..	14·39	—	3	40	—	—	2	3
3 ..	63·45	—	3	55	—	—	1	3
4 ..	15·86	4	4	63	4	4	2	3
5 ..	62·21	5	4	80	5	5	2	3
6 ..	7·51	6	5	101	6	7	2	3
7 ..	12·20	10	4	130	10	11	2	3
8 ..	13·33	12	6	145	12	12	2	3
9 ..	11·26	16	5	161	16	16	2	2
10 ..	9·01	19	4	226	19	19	2	3
11 ..	16·49	22	4	242	22	22	2	3
12 ..	6·71	24	5	247	24	24	2	3
13 ..	1·83	26	5	237	26	26	2	3
14 ..	26·29	28	6	224	28	28	2	3
15 ..	13·56	29	6	243	29	29	2	3
16 ..	21·75	31	6	177	31	31	2	3
Total	363·43							

Table II.—*Programme of Work.*

Date.	Item.
July 20, 1917 ..	Order received.
November, 1917 ..	Delivery of material commenced.
January 1, 1918 ..	Fabrication of structural parts commenced, also manufacture of fittings, equipment and machinery.
May 15, 7 a.m. ..	Keel laid.
May 26, 8 p.m. ..	Commenced running shaft lines.
May 27—	
6 a.m.	Shaft lines run; commenced installing boring bars.
2 p.m.	Commenced cut on starboard strut; cutting time, 35 hours.
5 p.m.	Commenced cut on port strut; cutting time, 48 hours.
9 p.m.	Commenced cut on starboard tube; cutting time, 42 hours. Also commenced cut on port tube; cutting time, 41 hours.
May 29, 6 p.m. ..	Boring, facing and drilling completed, and bars and motors removed.
May 29-31 ..	Four tanks water-tested.
June 1, 8.20 p.m..	Vessel launched.
June 6	Commenced installing auxiliary machinery.
June 15	Two tanks water-tested.
June 18	One tank water-tested.
June 19	Three tanks water-tested.
June 24	Vessel docked.
June 27	One tank water-tested.
June 28	All boilers installed.
June 29	Three compartments water-tested.
July 1	One compartment water-tested.
July 2	Two compartments water-tested.
July 3	Three compartments water-tested.
July 8	Shafts installed.
July 15	Vessel undocked.
July 17	Commenced installing reduction gears.
July 23	Three compartments water-tested.
July 24	Work completed in store rooms and officers' and men's quarters. Vessels commissioned.
July 25	Completed installing reduction gears.
July 27	Four compartments water-tested.
August 2	Commenced installing turbines.
August 9	Completed installing turbines.
August 22 ..	Commenced lighting up boilers and dock trials.
August 25 ..	Installed wireless fittings.
August 29 ..	Vessel docked to instal propellers.
August 30 ..	Vessel undocked.
September 1 ..	Ship left for sea trials, returning later with machinery defects.
December 7 ..	Machinery trials satisfactorily completed and ship left for service.

As large an amount of work as possible was assembled and riveted on the ground. Before the keel was laid the members so prepared consisted of:—The keel in sections with angles attached; all the bulkheads complete with boundary bars; the web frames and beams; the frames with floors, and bulkheads if any, attached; the deck houses complete; and the stern of the ship as far forward as 24 ft. from the after end. This work involved driving 183,000 rivets out of the total of 348,000 used. A comparison of Fig. 1, on page 543, and Fig. 4, on page 552, with the dates given, suggest the extent of preliminary construction away from the slip before the actual keel laying.

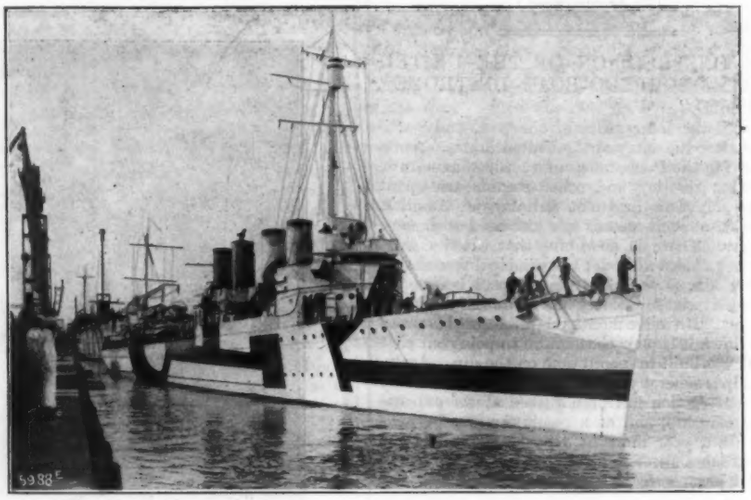


Fig. 3. The "Ward" Leaving for Trials, September 1, 1918.

The Yard officers were very successful in obtaining and encouraging a spirit of enthusiasm and sporting emulation amongst the men. The names of all workmen engaged on this attempt to establish a record were posted on a bulletin board, the name of the man, L. A. Towers, who returned the best rivet record, 13,343 shell rivets ($\frac{1}{2}$ in. to $\frac{3}{4}$ in.) in 10 working days or 97 hours, was published far and wide throughout the States. "Slogans" were prominently displayed about the vessel. "Thirty days or Bust" was promptly hauled down when it was seen that this programme would be easily beaten. The keel laying shown in Fig. 1 was made an occasion for a patriotic rally, the Commandant of the Yard heading a procession of workmen to the slip. A naval band or local talent provided entertainment alongside the vessel daily during the dinner interval.

The actual time between the laying of the keel and launching was seventeen and a half days. When launched the ship was well advanced as can be seen from Fig. 2, on page 543. She was estimated to be about 84 per cent. complete. Bulkheads, shell plating, frames, tanks and decks were riveted, with the exception of some plates over the boiler rooms left bolted for shipping boilers; the bilge keel, fenders, propeller guards, deck houses, bridges, searchlight platforms, masts, stowage for boats, and various deck fittings were installed and riveted in place. All outboard castings were fitted and shaft tubes and struts were bored. The work done and the number of men employed while the vessel was on the ways are given in Table I. Little night work was done. Thirty-three helpers worked seven nights and four helpers worked five nights. While boring shaft tubes the bars ran twenty-four hours per day and the men worked in 12-hour shifts.

The progress of the work is given in Table II, which also shows the time taken on the various operations of importance. This performance may be summed up as follows:—

Five and a half months elapsed between the receipt of the order and the commencement of work on material delivered; four and a half months later the keel was laid; the time on the slip, seventeen and a half days, was a record; the time, seventy days, between launching and commissioning was very short, but the vessel when commissioned was in a very incomplete condition; the ship left for trials three and a half months after the keel was laid, a very good performance; unfortunately the trials were not satisfactory, some defects developed in the feed pumps, the vessel had to return to the dockyard and remain there some months for these pumps to be removed and replaced. The interval between the date of receipt of order and the date of delivery, if no mishap had occurred on trials, would have been thirteen and a half months, which is not very noteworthy; actually this interval, which is the time that matters, was seventeen months three weeks, and this is by no means a record.

On service the ship has not given any indication of any evil effects arising from rapid construction.

Registration of Trade Marks in Brazil.—The Department of Overseas Trade is in receipt of a despatch from the British Chamber of Commerce of Sao Paulo on the subject of the registration of trade marks in Brazil. The Chamber notifies that it has now made definite arrangements with an eminent lawyer in Rio de Janeiro to handle and execute all applications for the registration of trade marks. The cost of such registration varies between 8*l.* and 15*l.*, the average being approximately 10*l.* The period of registration is for fifteen years. A special register is kept by the British Chamber of Commerce at Sao Paulo of all trade marks registered in Brazil. At the time of inscribing new British or foreign trade marks in this book, marks already registered are carefully inspected, and should any infringement be noticed, the British firm thus affected is immediately advised. In a recent article published in the monthly report of the British Chamber of Commerce in Sao Paulo, stress is laid on the importance of registering trade marks in Brazil in order to prevent unfair competition and infringement. It is pointed out that even if Brazil is not at present of interest as a possible market it does not follow that it may not become so in the future, and if at such time the exporter finds that another party has previously registered his mark no redress is possible. It is only by prior registration that the goodwill and use of the trade mark may be reserved. According to Brazilian law a manufacturer or trader has the right to distinguish his merchandise or products by means of special marks stamped on the articles themselves or on the receptacles or wrappers containing the said articles. The law on trade marks also provides that in order to secure the exclusive use of the trade mark, its registration, deposit and publicity are indispensable. Foreign trade marks without distinction have to be presented to the "Junta Commercial" of Rio de Janeiro, and the application for registration must be accompanied by a declaration of what constitutes the trade mark and a full description of it, the class or industry it is to represent, the profession of the applicant and his address. The interested party must have the certificate of registration published in the *Diario Official* within 30 days after the trade mark has been accepted by the "Junta Commercial." The regulations in regard to registration can be consulted by firms interested at the Department of Overseas Trade, 73, Basinghall-street, London, E.C. 2. Criminal procedure may be used against any party making use of a trade mark which is not registered and to which he is not entitled or which infringes a trade mark already registered. It is evident, therefore, that British exporters who ignore this disposition of the law and export an article bearing a trade mark registered in England but not in Brazil, are liable to be proceeded against criminally should the trade mark have been previously registered in Brazil by another party. Firms should register their trade marks in Brazil without delay.

WIRELESS DIRECTION FINDERS.*

By CAPTAIN H. RIALL SANKEY, C.B., R.E.

(*Concluded from page* 524.)

Modern Direction-Finding Apparatus.—In the apparatus I shall now describe the aerials are fixed and the readings are taken by rotating a small handle, as diagrammatically illustrated in Fig. 14. Inside the box seen in this figure there are two fixed coils known as field coils. These are mounted in planes at right angles and connected to the aerials, as indicated in Fig. 15. Within the fixed field coils is a rotatable search coil diagrammatically illustrated in Fig. 16.

The function of this portion of the apparatus is to combine the signals received on the two aerials in such a manner that the movable search coil is influenced by them when it lies in a plane corresponding to the direction from which the signals are received, and is unaffected when it lies in a plane at right angles to that direction.

Each aerial receives best from a transmitting station in its own plane. Thus if the sending station lies in the plane of the aerial A, the aerial B will receive nothing, and the search coil must lie in the plane of the fixed coil *a* to receive signals of maximum strength. If, under these conditions, the search coil lies in the plane of the fixed coil *b*, it will receive no signals. If the sending station is in the plane of the aerial B the conditions will be reversed.

When the sending station lies in a direction which is not directly in the plane of either aerial, both receive signals, and the strength in each is proportional to the cosine of the angle between the direction of the sending station and the plane of the aerial. It follows that when this occurs the two fixed coils act in the same way as an imaginary fixed field coil in a position intermediate between *a* and *b* corresponding to the direction from which the signals are received. In other words, as already pointed out, the two fixed aerials A and B, with their corresponding fixed coils *a* and *b*, are equivalent to an imaginary movable system, consisting of one field coil and one aerial, which automatically adjusts itself to lie in the plane of the incoming signals.

The direction of the sending station can be ascertained, therefore, by rotating the search coil until the signals are of maximum or minimum strength, and noting its position. In practice the minimum is used, since it is more sharply defined.

A standard modern direction-finding installation comprises the following, with appropriate auxiliary gear, such as batteries and telephones :—

1. A special aerial system.
2. The direction-finder coils and pointer.
3. A special transformer.
4. The detector.

Where space is a secondary consideration, as is usually the case in permanent land stations, large aerials may be used, and the components 2, 3 and 4, together with the necessary auxiliaries, can be installed as separate units. For use on board ship and in aircraft special aerial systems are provided to suit individual cases, and the remaining components may be arranged in a compact form as one unit.

The installation I am about to describe is for use on land, and has its components arranged as separate units. Fig. 17 is a sketch of an actual station, and as it is drawn to scale it gives an accurate idea of the proportions of the aerial system. This comprises one 90-ft. central mast supporting two triangular aerials with inclined limbs 110 ft. long, and horizontal limbs 144 ft. long. The latter are broken at the centre and led down to the instruments in the manner indicated in Fig. 18. Fig. 19 is a view of the gear inside the wireless cabin. The external appearance of the direction-finder box is illustrated in Fig. 20. Fig. 21, page 546, is a view showing the inside, and Fig. 22 a diagram of the connections.

In the land pattern direction finder the two aerial circuits are tuned by means of separate condensers which are connected to the terminals B C and F G. By tuning is meant that the circuits are adjusted to oscillate at the same frequency as the incoming wave.

The field coils *a* and *b*, Fig. 22, are each connected in circuit with one of the aerials by means of the terminals A D and E H. These coils are split at their centres, whence leads are taken to the terminals B C and F G, thus enabling the condensers to be connected at points of symmetry in the aerial system. In the space within the coils is mounted the rotatable search coil S, which is connected to the detector through a special transformer.

As will be seen in Figs. 20 and 21, the search coil is mounted upon a vertical spindle provided with a handle and pointer which moves over a fixed scale graduated in degrees. For use on land it is arranged that 0 deg. on this scale is the minimum point for signals received from stations on a line running true north and south from the direction finder. On ships and in aircraft 0 deg. is the minimum point for stations on a line directly ahead and astern. It should be noted that when once the circuits are tuned and the aerials balanced one-half of the scale only need be used, for, as it makes no difference which way round the search coil may be so long as it lies in the desired plane, opposite points on the scale are equivalent. Thus in the standard instrument aboard ship, for example, signals from dead ahead are of minimum strength when the pointer is at 0 deg., and also when it is at 180 deg., and they are full strength when the pointer is at 90 deg. or 270 deg.

From a consideration of the foregoing it will be realised that the standard direction finder indicates direction, but not what is mathematically termed "sense," *i.e.*, it enables the operator to ascertain that

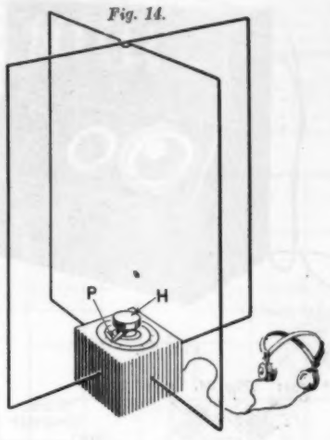


Fig. 14.

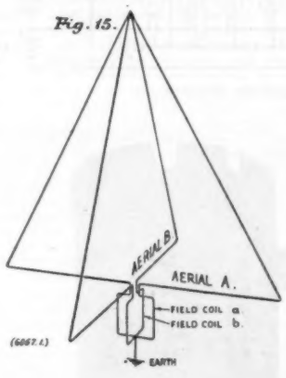


Fig. 15.

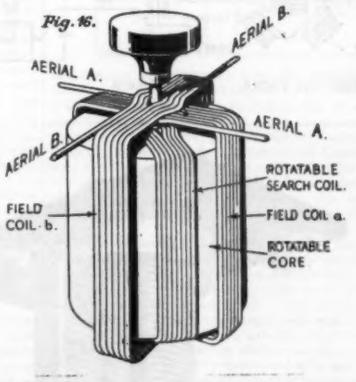


Fig. 16.

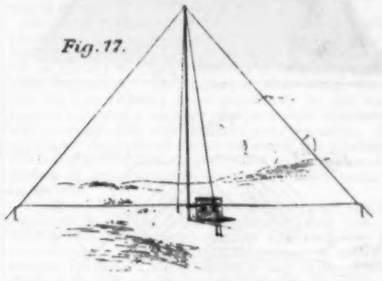


Fig. 17.

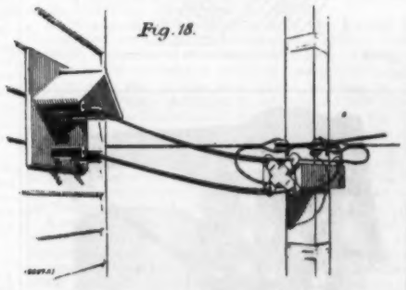


Fig. 18.

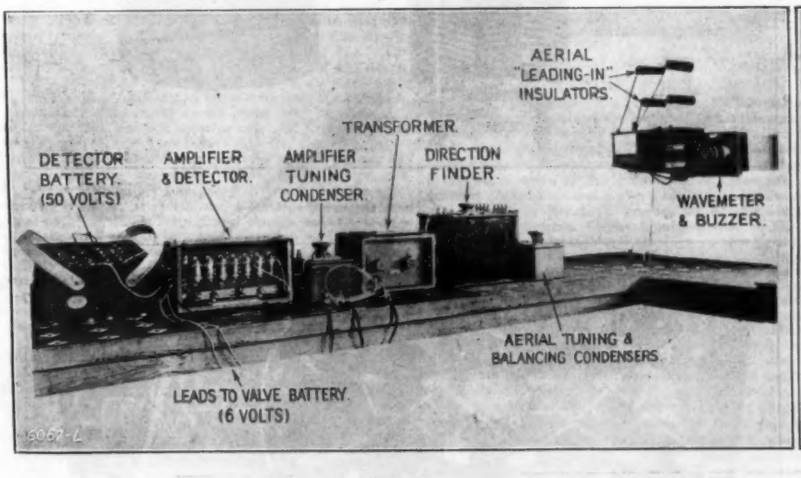


FIG. 19.

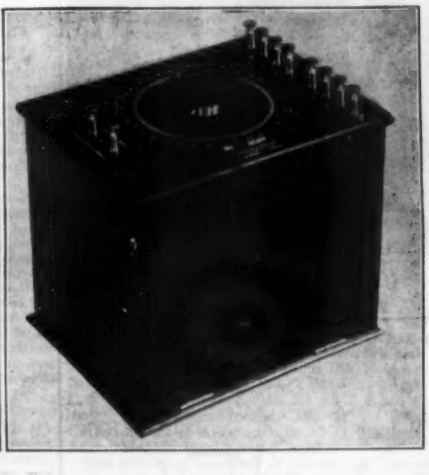


FIG. 20.

* Lecture at the Olympia Exhibition, October 9, 1919.

WIRELESS DIRECTION FINDERS.

Fig. 21.

Fig. 23.

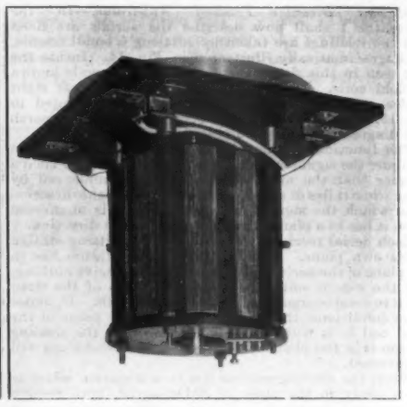
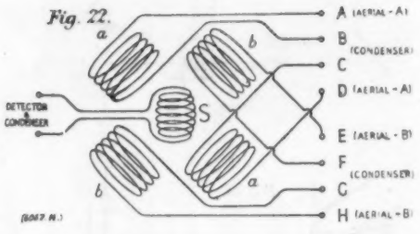
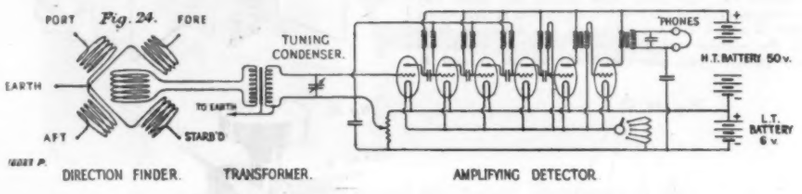


Fig. 25.





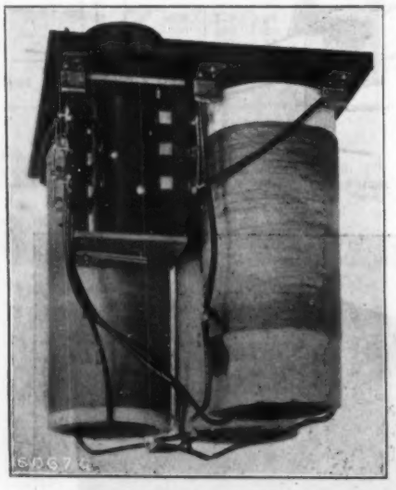


Fig. 26.

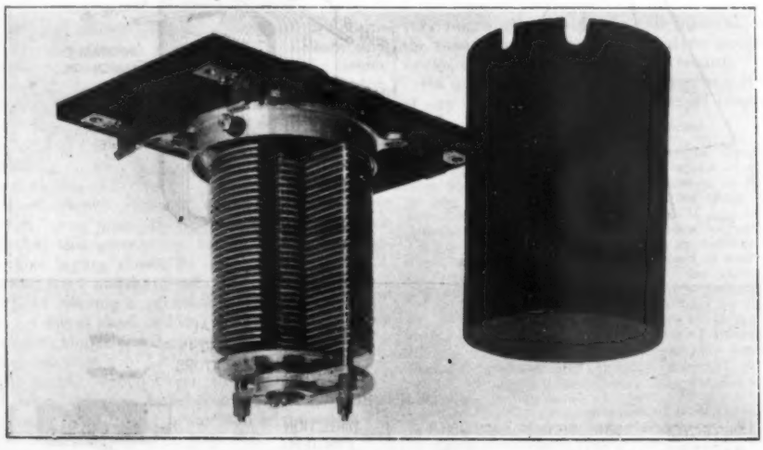
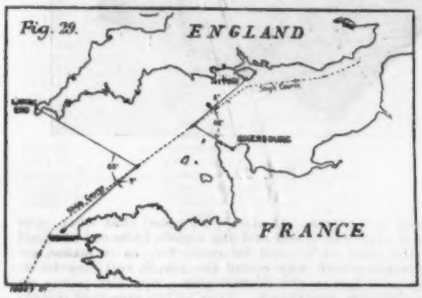


Fig. 27.



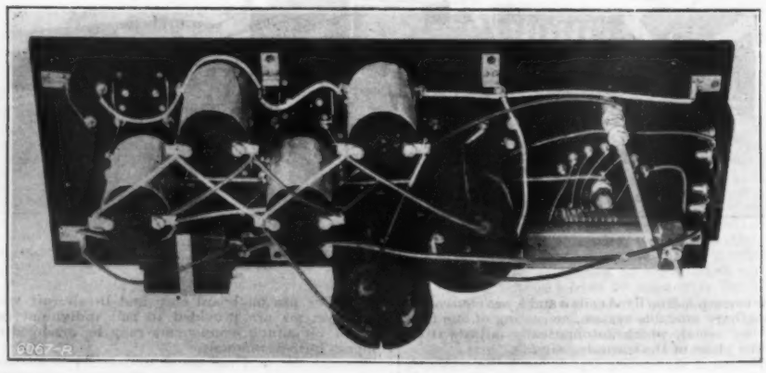


Fig. 28.

a given station is on a line running north and south for example, but gives no indications as to whether it lies to the north or to the south. In practice this peculiarity does not detract from the value of the instrument, excepting in the special case of one ship or aircraft being desirous of ascertaining, with great rapidity, the relative course of another. In such a case, if wireless communication can be obtained, a combination with the direction-finder reading will give the required information.

I will now briefly describe the new marine pattern direction finder, to which I have previously referred. It is a simplified form which is particularly easy to operate, as there are no complex tuning adjustments, all that is necessary being effected by turning one handle, the sharpness of tuning is satisfactorily maintained, and, owing to the incorporation of an amplifying detector of the most recent type, the receiving range is

very considerably augmented. Fig. 23 is an external view, and a simplified diagram of connections is given in Fig. 24.

With the exception of the batteries and the operators' 'phones, the whole of the apparatus is contained in the small compactly-designed unit, which is illustrated in Fig. 23. In the teak case forming this unit are four metal-lined electrically-shielded compartments for the four component pieces of the apparatus, namely, the direction-finder coils and pointer, the transformer, the tuning condenser and the amplifying detector. Each component is built up on an ebonite panel corresponding in size to the front of its compartment, and is held in position by ebonite capped brass holding-down screws, which also serve as electrical connections.

This type of construction permits of any component being easily and rapidly removed for inspection and cleaning without in any way disturbing the remainder of the gear and without the necessity for breaking any soldered joints. Thus, in case of accidental damage, any component may be replaced on the spot, thus avoiding the necessity of returning the complete apparatus for repair. The appearance of the direction-finder component when removed from its compartment on the left of the containing case is illustrated in Fig. 25. It may be described as what is known in wireless as a "tightly-coupled" high frequency transformer having two independent primaries or field coils at right angles, embracing a rotatable secondary or search coil as in the case of the loosely-coupled land pattern direction finder. Each of the field coils has its centre point earthed, and is in circuit with one aerial, and the search coil is connected to the detector through the special transformer described below.

The transformer component, which is illustrated in Fig. 26, consists of three highly-insulated air-cored transformer elements, together with a range-changing switch. The windings of the transformer are designed for wave-lengths of 300 m. to 800 m., 750 m. to 2,000 m., and of 1,900 m. to 4,800 m., but the exact ranges obtained will depend upon the size of the aerial. If the aerial is unusually large there will be a slight increase in all wave-lengths, and with a small aerial there will be a slight reduction. Between the primary and the secondary windings of each transformer element is an electrical shield, consisting of a copper sheath, which is connected to earth. The function of this shield is to protect the detector from action of the non-directional component, to which I have previously referred.

Tuning over the whole range corresponding to any setting of the switch is provided for by a specially-designed variable air condenser, Fig. 27.

Rotation of the circular ebonite handle on the face of the panel carrying this component alters the relative position of the two sets of the vanes forming the condenser and so brings about the smooth and continuous variation in capacity necessary for rapid and accurate tuning. The manner in which the vanes interleave more or less as the handle is rotated will be evident on reference to the illustration.

The amplifying detector, of which Fig. 28 is a rear view, is mounted in the upright portion of the teak case, the front edge of which projects beyond the supporting panel by an amount sufficient to minimise the risk of mechanical injury to the valves. There are six valves altogether. The four on the right-hand side are of the "V.24" pattern. The function of these is to amplify, in four stages, the high frequency currents from the transformer. The fifth valve, which is of the "Q" pattern, acts as a rectifier or detector, and the sixth, a "V.24" performs the functions of a "note magnifier," *i.e.*, it amplifies the rectified signals in the phone circuit.

On the left of the panel is a six-point variable resistance and switch for controlling the filament currents, and above this is a circular ebonite handle, the rotation of which regulates the electric pressure on the valves, by acting on another resistance called the potentiometer. In practice it is rarely necessary to touch the potentiometer or rheostat after the amplifier has been put into operation, but it is sometimes convenient to reduce the strength of signals emanating from near by or high-power stations. In such cases the valves may be dimmed by the adjustment of the variable resistances and the potentiometer set at an insensitive position.

I will conclude my lecture by taking two examples to illustrate the use of the direction finder:—

Suppose that a ship coming up the English Channel in foggy weather is somewhere to the west of the Channel Islands. It would ascertain its position by taking wireless bearings on Lands End and Ushant, a third reading on, say, Cherbourg, providing a check on the accuracy of these observations if required.

Under the conditions shown in Fig. 29 the direction finder indicates that Land's End is somewhere on a line making an angle of 66 deg. with the fore-and-aft line of the ship, and that the corresponding angle for Ushant is 5 deg. The direction in which the ship is heading is known, since it is given by the ordinary compass, and it is therefore a simple matter to combine the observations and set out the ship's position on a chart. Readings may be taken at frequent intervals if necessary, other stations such as Niton, Cherbourg, North Foreland, &c., being utilised as the ship proceeds on its course.

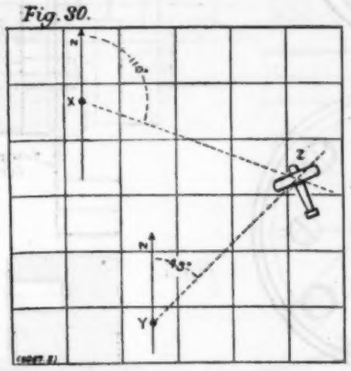
It may be mentioned that it is not always necessary to ascertain a ship's position, the direction of a known point being often all that is required. In such cases one observation only is necessary, as for example in ascertaining whether a ship's course will take it inside or outside a lightship or isolated lighthouse. A wireless signal from the lightship or lighthouse will settle the question as certainly as if the light were visible. Similarly, when about to enter harbour, signals from a station in the harbour will show immediately if the ship has drifted to one side of the entrance.

Apart from its use aboard ship it will be realised that the wireless direction finder is applicable to aircraft navigation, and it is evident that in this sphere it must prove to be of extraordinary value. It has been said, in fact, that the future of commercial aviation is bound up in the development of this method of navigation, and when it is borne in mind that any really commercial transport service must be reasonably independent of weather conditions, it will be realised that this is not an altogether extravagant claim.

Aircraft fitted with the wireless direction finder are navigated in the manner just described, but if ordinary wireless only is carried, navigation must be carried out by means of fixed direction-finding stations on the ground.

Referring to Fig. 30, let us assume that X and Y are two fixed direction-finding stations which have been called up by the aeroplane Z with a view to ascertaining its position. From the wireless signals sent out by Z

Fig. 30.



the station X ascertains that the aeroplane is on a line making an angle of 110 deg. with true north, and at the station Y the angle is found to be 45 deg. The two directions so found are at once communicated by telegraph or telephone to the control station, where, by drawing corresponding directional lines upon a chart and noting the point of intersection, the position of the aeroplane is ascertained. A brief wireless message from the control station then advises the aeroplane of its whereabouts at the time the directional readings were taken.

Conclusion.—I have attempted, in the brief space of 1 hour, to explain the principle and action of the wireless direction finder and to indicate the method of its application to the problem of navigation at night and under adverse weather conditions. The subject may be said to bristle with abstruse technical considerations, and it has not been possible to avoid altogether questions of detail, but it has been my endeavour to avoid unnecessary reference to the highly technical side and to put forward my explanation as far as possible in simple language and in a clear manner.

INTERNATIONAL ELECTROTECHNICAL COMMISSION.

THE International Electrotechnical Commission has not held any meetings during the war, although it has successfully maintained its central organisation intact. Now that peace has come again, reconstruction is occupying its attention, and in order to make quick progress, in spite of the difficulties of transport, it was decided to hold a meeting in London, and this meeting was opened on Monday, October 20, at the Institution of Civil Engineers, Great George-street, S.W. 1, by M. Maurice Leblanc, the President of the Commission, 18 countries being represented by some 52 delegates.

Sir Richard Glazebrook, C.B., in welcoming the foreign delegates on behalf of the British National Committee of the Commission of which he is chairman, regretted the fact that Mr. A. J. Balfour, who had addressed the delegates in 1908, was most unfortunately unable to be present on this occasion; he had, however, written expressing the keenest interest in the work, and it was Sir Richard Glazebrook's hope that he might yet be with the delegates before the close of their meetings.

Sir Richard Glazebrook then referred to the pioneer work in electrical standardisation carried out by the Electrical Standards Committee of the British Association—of which, for many years, he had acted as secretary. This work had been international in its character, and had laid the foundation for the industrial superstructure which the Commission was now endeavouring to complete. In Great Britain the British Engineering Standards Association is responsible for electrical standardisation, and overlapping of effort is entirely avoided by the fact that the Sectional Electrical Committee of the association is, *ipso facto*, the British section of the International Commission. Mr. Roger Smith, the president of the Institution of Electrical Engineers, also extended a very hearty welcome to the foreign delegates, and Mr. A. R. Everest, on behalf of the British Electrical and Allied Manufacturers Association, joined with the previous speakers in offering the industry's cordial greeting to the eminent electrical engineers present.

The president of the Commission, M. Maurice Leblanc, then gave an interesting address, in the course of which he referred to the fact that the Commission owed its inception to the Chamber of Delegates at the St. Louis Congress in 1904, at which Colonel R. E. Crompton, C.B., had initiated the movement. He mentioned the fact that the late Lord Kelvin had been the first president. He also referred to the losses which the world of science and electrotechnics had sustained through the passing away of Dr. Sylvanus Thomson, F.R.S., Professor Eric Gerard (of Belgium), Mr. W. Duddell, F.R.S., Professor Jona (of Italy), and Mr. Von Krogh (of Norway). Speaking next of the great problems of reconstruction which lay before the electrical industry of the world, he mentioned the surprise it had been to him to realise how quickly his beloved country, France, had, during the war, become a national workshop, and he felt sure that they would be able to turn the experience they had gained through the manufacture of munitions to the manufacture of the engineering appliances required in everyday life.

M. Leblanc also referred to the tremendous sacrifices which had been made by the allied nations to obtain this great liberty, and hoped that in the future those who had suffered would, in some proportion obtain the freedom and better conditions for which they had fought. He wished the Commission every success in the work which lay before it, the most important of which was the establishment of an agreed basis for the comparative rating of electrical machinery and apparatus.

Mr. C. H. Wordingham, C.B.E., the immediate past-president of the Institution of Electrical Engineers, replied to the address and expressed the pleasure they all felt at having as their president an honorary member of that Institution. He remarked that while the allied nations had suffered most grievously in the war, the neutral nations, a number of whom were represented at this meeting, had also suffered very severely. He felt sure that the glorious nation of which the president was the honoured representative would be unsurpassed in the period of reconstruction as it had been unsurpassed in the war.

Signor Guida Semenza, past-president of the Italian Association of Electrical Engineers, and one of the founders of the Commission, in thanking the British committee for their welcome, expressed on behalf of the foreign delegates, the pleasure it was to them all to be present at this meeting, and take part in what he felt was a work of immense importance to the future welfare of the electrical industry of the world.

Dr. C. O. Mailloux, president of the United States Committee, who, through his linguistic ability, had from the very inception of the Commission been of the greatest service to the movement, acted as interpreter during the proceedings, and at the close of the meeting, on behalf of the American delegation, suggested that the next meeting of the Commission should be held in the United States of America, where he knew the delegates would, one and all, be certain of receiving a very hearty welcome. Monsieur Brylinski, the president of the French Committee, supported Dr. Mailloux's suggestion, and it is probable that at the plenary meeting which is to be held on Wednesday next, this proposal will be adopted.

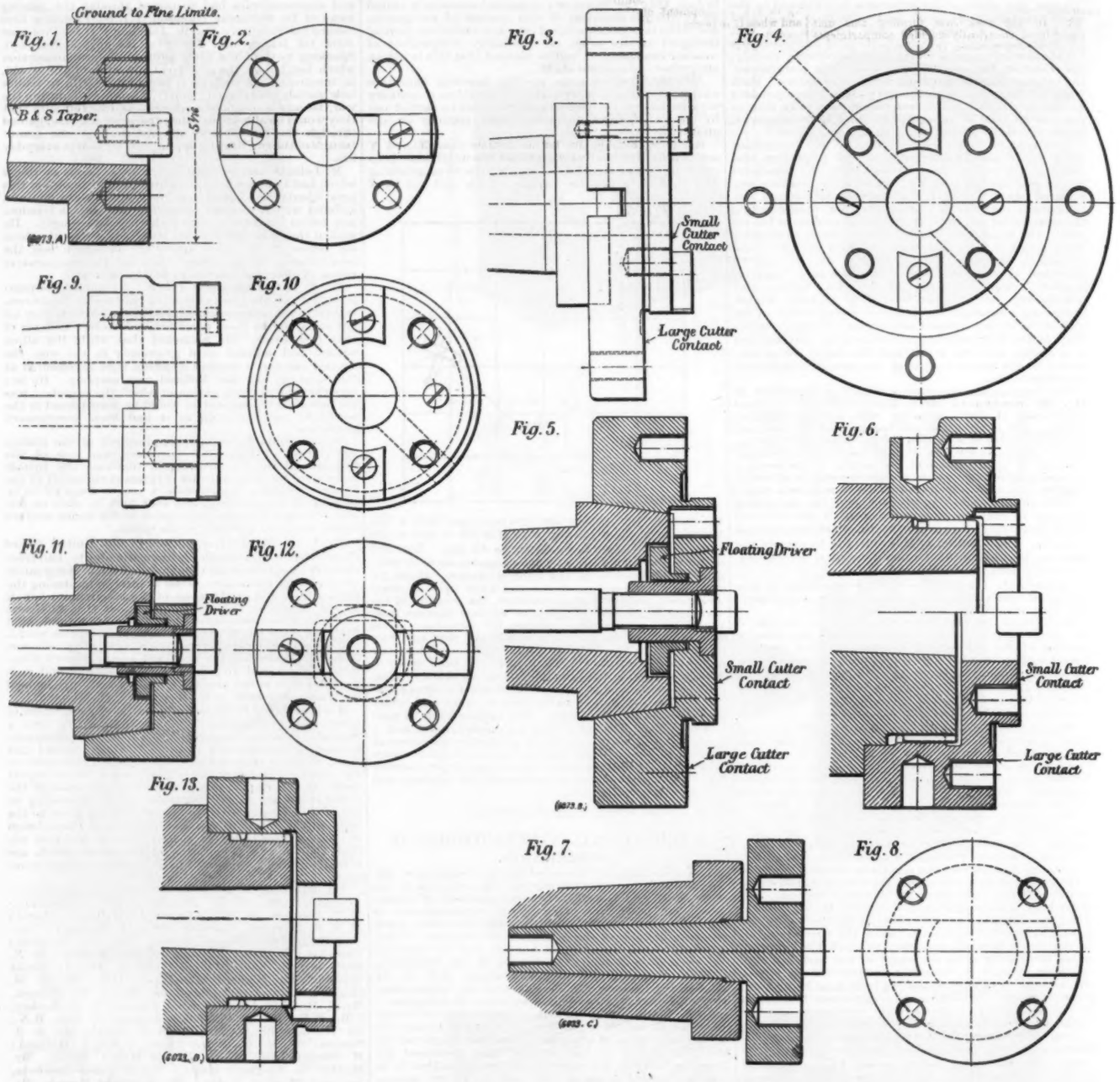
A whole day is to be taken up in the consideration of questions of reconstruction. In addition to this a Special Committee on the rating of electrical machinery is meeting continuously in order to push forward this work, which is regarded as of the highest importance to the electrical industry, more particularly to its export trade, and in respect of which definite proposals of the Commission are eagerly awaited. It is interesting to note the increasing attention which is being given to the work of the International Electrotechnical Commission by the manufacturers of the world who are now co-operating in the preparation of standards which are bound to be of increasing utility to international commerce.

The following is a list of the delegates present:—Australia: Mr. G. H. Knibbs, C.M.G.; Belgium: M. E. Cevaert, M. le Professor A. Halleux; Brazil: M. M. de Oliveira; Canada: Mr. A. P. Trotter; Chili: Eng.-Com. Don Roman Suarez, Eng.-Lt. Migueles; Denmark: Professor Albsalon Laruen; France: M. E. Brylinski, M. Paul Boucherot and M. David; Great Britain: Sir Richard Glazebrook, C.B., Mr. F. M. Chapman, Mr. J. E. Edgcombe, Mr. A. H. Everest, Mr. C. Rodgers, Dr. A. Russell, Captain H. R. Sankey, C.B., R.E., Mr. C. P. Sparks, Captain J. Slee, R.N., Sir William Slingo, Mr. Roger T. Smith, Mr. A. J. Stubbs, Mr. C. H. Wordingham, C.B.E.; Holland: M. Barnet Lyon, M. le Dr. de Haas; India: Mr. Maurice G. Simpson; Italy: Signor Guido Semenza, Professor Morelli; Japan: Mr. Motosuke Masuda, Mr. Motoo Uchisaka; Mexico: Senor Ing. D. Arturo Pani; Norway: Eng. J. C. Holst; Poland: M. Czainomski; Portugal: Colonel J. Lucas, Mr. E. S. Lane; Switzerland: Mr. Huber-Stockar, Mr. A. de Montmollin; United States of America: Dr. C. C. Mailloux, Messrs. Burke, Hobart, Chubb and Kemble.

The following members of the British National Committee were also present:—Lieutenant-Colonel Robertson, R.E., Mr. J. H. Bowden, Mr. W. McClelland, Mr. W. R. Rawlings, Professor T. Mather, Mr. W. M. Mordey, Mr. G. Scott Ram, and Mr. P. F. Rowell.

TUNGSTEN MINERALS IN AUSTRALIA.—During the war the tungsten minerals of Australia, wolfram and molybdenite, which had been exported to Germany, were taken over by the British Government. Australian technical journals now complain that the mines in New South Wales and the smelting works in Sydney have to close down because they are not able to conform to the ore standard of the Government. It is said that Australia received during the war, 400*l.* and 500*l.* per ton of ores, for which the British Government paid Norway and Sweden four times as much. The whole aspect of the tungsten industry had, of course, changed during the war.

STANDARD SPINDLE NOSES FOR MILLING MACHINES.



STANDARD SPINDLE NOSES FOR MILLING MACHINES.

To the Editor of Engineering.

Sir,—The subject of standard spindle noses for milling machines is by no means novel; but as the circumstances under which investigations recently took place were private and confidential, it is impossible to refer in detail to the proceedings here; we might say, however, that a representative of Messrs. A. Herbert, Limited, was present at all the meetings.

The scheme put forward by Messrs. Alfred Herbert is very interesting in so far as it represents the views of a firm of high repute, but this fact alone does not justify the adoption, as a standard, of the particular spindle nose as made by them. The views of other firms may, therefore, be of some value, and the result of an open discussion may lead to the adoption of a standard which would be satisfactory to the majority of manufacturers and users.

For some time past four members of the Associated British Machine Tool Makers, Limited, viz., Messrs. James Archdale and Co., Limited, Kendall and Gent, Limited, J. Parkinson and Son, and Smith and Coventry, Limited, have interchanged ideas upon the subject, examined various types of spindles, and have each tacitly agreed upon the adoption of a standard at some convenient time. Their decision has been to adopt the type of spindle nose used by several American firms. This type is indicated in Figs. 1 and 2.

In this design a slot is milled across the end of the spindle, and hardened keys are fitted and secured by screws. It does not affect the question of standardisation whether the keys are loose or not, and some firms whose policy is to harden the spindles throughout may prefer to make them solid with the spindle.

The spindle end is ground to a standard diameter, which ensures that all standard face cutters will fit thereon. The cutters are secured by means of four screws which enter the holes as shown. The cutter is first lifted into the spindle and drawn up securely by the usual drawbolt, then fastened by the four screws.

The advantages of this construction are, the driving key is effective up to the full diameter of the spindle end, the cutter is easily and accurately applied, and it is secured by the screws on a circle of maximum diameter permissible by the dimension of the spindle end.

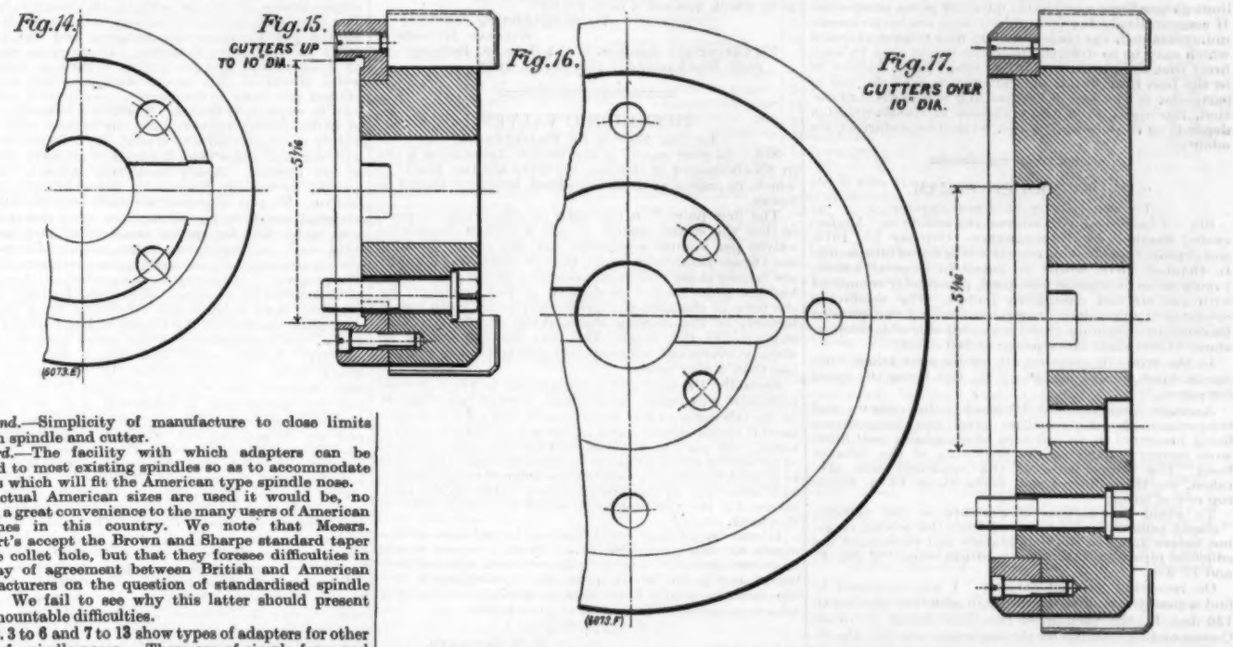
This latter feature ensures steadiness of cutter under the action of heavy cuts, and is preferable to the method where the cutter is held to the spindle by a long drawbolt only acting at the centre of the cutter, especially where large cutters are used. A long bolt acting thus and in tension is not calculated to resist a tipping tendency of the cutters so well as short screws applied near the periphery.

The design shown may be considered suitable for face cutters up to, say, 10 in. diameter. For larger cutters the spindle would be flanged in a similar manner to the adapters shown in Figs. 3 to 6 and provided with a second row of tapped holes. The spigot being of the same diameter as the nose in Fig. 1 enables 10-in. cutters to be accommodated also. It is important to note that the large cutters bear on the flange and are clear of the spigot face, whereas the 10-in. cutters fit against the latter.

The choice of this type of nose was influenced by consideration of the following points:—

First.—Large numbers of machines by American firms of high repute embodying this type, with slight modifications, are used in this country. One of these firms state having transmitted 80 h.p. through spindle noses of this type. This is clear evidence of the satisfactory nature of the drive.

STANDARD SPINDLE NOSES FOR MILLING MACHINES.



Second.—Simplicity of manufacture to close limits of both spindle and cutter.

Third.—The facility with which adapters can be applied to most existing spindles so as to accommodate cutters which will fit the American type spindle nose.

If actual American sizes are used it would be, no doubt, a great convenience to the many users of American machines in this country. We note that Messrs. Herbert's accept the Brown and Sharpe standard taper for the collet hole, but that they foresee difficulties in the way of agreement between British and American manufacturers on the question of standardised spindle noses. We fail to see why this latter should present unsurmountable difficulties.

Figs. 3 to 6 and 7 to 13 show types of adapters for other kinds of spindle noses. These are of simple form and easily render existing machines available for using cutters to the new standard, proposals for which are shown in Figs. 14 to 17. The normal projection of this spindle nose is no greater than that of the taper form already submitted, nor do the adapters greatly increase the overhang. The adapters for screwed spindle noses could be provided with a central bore large enough to admit the collar of the arbor normally used. This bore could, if necessary, be of the special form to drive the arbor, so that the adapter could remain permanently on the screwed nose, and the question of the thread seizing would not arise.

The discussion so far has been limited to standardisation as affecting face cutters attached to spindle noses. We suggest that the whole question be thrashed out with a view to securing interchangeability of arbors.

We are, yours truly,

JAMES ARCHDALE AND CO., LIMITED.

Birmingham.

LIMITS FOR GAUGES FOR HOLES.

TO THE EDITOR OF ENGINEERING.

SIR,—There have been many references lately in your journal to the vexed question of limits for gauges for holes. As the pioneer British firm in the establishment of a standardised system of limits, we are naturally very interested in the decision shortly to be arrived at by the British Engineering Standards Association. As one of the chief features of a system the association appears to be supporting is somewhat at variance with our established practice, we should be glad of an opportunity to place before your readers a number of reasons why, in our opinion, the proposal of the British Engineering Standards Association to make the nominal size the low limit for all holes will not be in the best interests of the majority concerned. We therefore send you the enclosed "Summary of Reasons in Support of Plus and Minus Limits for Holes," and trust you will see your way to publish this at your earliest convenience.

In conclusion, we should like to draw your attention to the fact that the reasons we have given are *not* reasons based on Newall vested interests, but are reasons deduced as far as possible from a commonsense view of the position as it stands. Thanking you in anticipation,

We are, yours faithfully,

THE NEWALL ENGINEERING COMPANY,
R. J. BRAY,
General Manager.

Blackhorse Lane, Walthamstow, London, E. 17,
October 17, 1919.

Summary of Reasons in Support of Plus and Minus Hole Limits.

N.B.—In the following all limits are assumed to be the limiting sizes of the gauges used; the limits, therefore, refer to the gauges and not to the work.

The reasons in support of plus and minus hole limits can be divided in order of importance, into two main groups:—

I. Practical reasons dependent on existing and past practice.

II. Theoretical and other practical reasons.

In Group I *are*:—

1. Existing stocks of reamers and mandrels are suitable for holes of standard size, to obtain which with the advantageous use of limit gauges the low limit must of necessity be below the nominal.

2. Of all drawings extant which are limited with standard limits, *i.e.*, with the published limits of any of the well-known systems, probably not less than 99 per cent. call for holes with plus and minus limits, and any change of system involving an increase of the hole size as great as that produced by making the nominal size the low limit for all holes could not possibly be applied to these drawings without to a large extent involving a sacrifice of interchangeability as between the old and the new.

3. All the standard limit systems in use in this country with the possible exception of the old E.S.C. limits, and certainly all the oldest and best-known systems in use on the Continent, have plus and minus hole limits, so that the proposal to raise the average size of all so-called standard holes cannot be adopted without considerable scrapping of gauges.

4. Ball and roller bearings as at present standardised will, in many cases, be most easily dealt with if the limits of the holes to receive the races are controlled by gauges with at least one minus limit.

5. Quite apart from the possible loss in the value of tools represented by reamers, mandrels and gauges, the introduction of a basis hitherto not in general use will necessarily entail much extra control and work where it is hardly warranted by the theoretical gain put forward in favour of the change. As all the desirable advantages of limit gauges can be obtained without such a change surely it is better "to let well alone" and develop a new system along lines that will fit in easily and without loss with existing practice.

Under Group II *are*:—

6. It is agreed that the new limit system contemplated is to be on the "hole basis," in other words to provide a series of fits, the hole is to be standard while the shafts are to be varied in size to give the required fits. This being granted, then it is logical that any error permitted in arriving at the standard hole aimed at, should not be all on one side, but should be allowed to be either plus or minus, so that the maximum departure from the standard size aimed at will never exceed half the total tolerance.

7. When the low limit is the nominal size, no hole can possibly be of standard size unless the "go" end of the gauge be forced into the hole, which in this case will be exactly the same size as the gauge. Under such conditions there is practically no margin for error, and the operator to obtain the desired result, namely, a standard hole, is obliged to exercise extreme care. Moreover, in forcing the gauge into the hole to obtain this desired result, he will injure the gauge, and if the operation be repeated the gauge will soon be worn and rendered unsuitable for use in a system in which the low limit is the nominal size. In order to avoid the risk of damaging the gauge, the system should be such that to produce the desired result, the gauge *should enter the hole freely*, and full opportunity should be given to the operator to take advantage of the permitted tolerance. With plus and minus limits, both these advantages can be obtained, while the majority of holes produced will be very close to standard size.

8. Where various qualities of work are dealt with, there is no valid reason why in coarse work the holes should be larger on the average than in fine work, as will be the result if the low limit for all qualities is the nominal size. The aim in each case should in general be to produce holes as near to standard size as possible within the margin allowed by the tolerance.

9. In most systems of limits, shafts have a progressively increasing tolerance as they recede in size from the nominal value. If, as would follow from Clause 8, the low limit for holes also recedes from th e nominal as the quality becomes coarser, the low limit for coarse holes will come down as it were to join the coarser shafts. One result of this is that it is possible to arrange matters so that one series of shafts in descending sizes may be made to serve for a wide range of qualities of work. This restriction of the number of shafts will simplify the problems of notation and will reduce considerably the cost of gauges to cover the whole range of engineering.

10. A final practical reason why it is suggested that the British Engineering Standards Association should abandon the proposal to have the low limit on the nominal line is that if the system promulgated by it has this feature, a very large number of firms will be unable to adopt the British Engineering Standards Association's new standards, because of the stock of gauges and tools they have used in the past for systems involving plus and minus hole limits, and also because of the disorganisation which would be caused by the change in their drawings. It will be thus impossible to avoid the perpetuation of plus and minus hole limits with the result that one of the chief objects of standardisation—uniformity—will not be obtained.

Looking at the matter from the other point of view, those firms at present working with limit systems embodying the feature of the low limit on the nominal line, are very few in number, and in all probability only a small proportion of them are actually using limit gauges. If these few can be persuaded to change to a system involving plus and minus hole limits, their gauges can be rendered suitable by merely grinding them down to the new sizes, and very little scrap will result.

As to the firms already using plus and minus limits, many of them will not object to change to a similar system provided it is backed by the sanction and authority of the British Engineering Standards Association, because the limits of such a system will necessarily not be very different from those at present in use. It is safe to anticipate that a large proportion of existing stocks of reamers, mandrels, and gauges will suit both systems, which in many cases might be used simultaneously during the transition period.

In conclusion, reference may be made to the chief argument put forward by those who are in favour of a low limit of nominal size. They contend that the number of present users of limit gauges is small compared with the many (now using standard plugs) who in all probability will adopt limit gauges in the near future. It is on this account that existing limit gauge practice is put aside as an unimportant factor in the settlement, while it is contended that the large majority who are working to standard plug gauges without a definite tolerance need only the addition of suitable high limit plugs to place them among the more enlightened who are already working with limit gauges.

It should be remembered, however, that standard plugs wear considerably if used in the shops, and that, in consequence, only a small proportion of such plugs will be serviceable for limit gauges with the low limit of nominal size. They may suit quite well for their present method of use, but when the making of pieces on an interchangeable basis is undertaken, the slackness of control of gauge sizes acceptable for the old, and still too prevalent method of fitting piece to piece, will no longer be admissible. It follows that if these gauges are to be used for a limit system, very careful preliminary

measurement will be necessary, and if serious scrapping is to be avoided, the low limit can only be fixed below the nominal.

Furthermore, the attitude that the present users of limit gauges form a negligible quantity is not acceptable. If comparatively few in number, they are by no means unimportant in the trade, and any new scheme of limits which may be so different from the limits used by such firms that they cannot afford to adopt them, cannot be in the best interests of the industry as a whole, nor in particular of the British Engineering Standards Association, the measure of whose success in standardisation depends on the extent to which its recommendations are adopted.

"UNDERCOOLED STEAM."

To the Editor of Engineering.

Sir,—I have read with interest the article on "Undercooled Steam" in Engineering, October 10, 1919, and perhaps the following results will be found interesting. In October, 1918, whilst on patrol in tropical waters, I ran a series of trials at low speed, principally connected with the air and circulating pumps. The machining consisted of a two-shaft arrangement with direct-coupled Brown-Curtis turbines, each turbine capable of developing about 11,500 shaft horse-power at 350 r.p.m.

In the trials in question all results were taken from one turbine running at 130 r.p.m., this being the speed for patrol.

Amongst various items I recorded the vacuum and temperature in the eduction pipe, the temperature being measured in an ordinary thermometer well filled with mercury, fixed at the beginning of the exhaust bend. The temperature of the condenser was also taken, the thermometer well being about 15 in. below top row of tubes.

To avoid fluctuations of pressure in the turbine, "closed exhaust" was removed from the second stage, but before doing so the temperature and vacuum of the eduction pipe were taken, the readings being 102 deg. F. and 27·9 in.

On removing "closed exhaust" I was surprised to find a steady rise of temperature in eduction pipe up to 126 deg. F., the vacuum at this limit being 27·75 in. Corresponding readings for the condenser were 101 deg. F. and 27·85 in.

With "closed exhaust" again put into the second stage the temperature of eduction pipe slowly fell to 102 deg. F., vacuum being 27·9 in.

The next day I carried out some similar experiments, but using different thermometers and vacuum gauges. Almost similar results were obtained, readings being: Eduction pipe, temperature 125·5 deg. F., vacuum 27·6 in. Condenser, temperature 102·5 deg. F., vacuum 27·7 in.

A thermometer was left in the eduction pipe all night with "closed exhaust" to the second stage, and the average temperature for vacuum of about 27·9 in. was 102 deg. F.

Yours faithfully,
S. F. Dorey, B.Sc., A.M.I.N.A.

Glenshee, Whickham, County Durham,
October 15, 1919.

[Our correspondent's observations are interesting, but it will be noted that they were not made in normal full load conditions. Presumably the actual load on the turbines was not much more than $\frac{1}{10}$th of the full designed output. Perhaps it was even less than this. In a series of careful observations on an exhaust steam turbine driving an electric generator, the exhaust temperature was found to be always lower than that corresponding to the pressure in the case of the runs made at full load, half load, and one-quarter load. At a still lower load, however, the exhaust proved to be superheated. In this series of trials the turbine was supplied with live steam slightly superheated. It is quite likely that in this case the last rows of the turbine blading were actually doing negative work.—Ed. E.]

UNIVERSITY MATHEMATICS FOR ENGINEERS.

To the Editor of Engineering.

Sir,—I would like to make a short reply to the letter in your issue of the 10th inst. on "University Mathematics for Engineers."

This will also be my last word on the subject, as the argument will have been fully stated on both sides, and no useful purpose will be served by continuing it.

Mr. Dunton's objection to the method I gave is that it is unnecessarily difficult. This is no argument against it when it is a *complete and correct* solution. Moreover, it is little, if any, more difficult than the solution he gave. He says that it is not so correct; I have yet to be advised of any flaw in the working. The matter of sign is very simply explained. In circular measure we accept the *convention* that the angle is positive if the radius vector travels in a contra clockwise direction and negative if it travels in a clockwise direction. The same convention is applicable to the hyperbolic function and would give the correct sign to

$$\int_0^p \frac{ds}{p}$$

In conclusion, if we define a function by its relation to a curve it is not usual to choose a particular case of that curve for the demonstration, and I think it will be generally admitted that a definition which holds for any case of the curve is more correct than one which is limited in its application to a very special case. In addition the method I advanced emphasises the complete analogy between the hyperbolic and circular functions which is quite obscured by Mr. Dunton's method.

The facts being fully explained, I feel quite confident in leaving to the judgment of your readers the question as to which method is more correct.

Yours faithfully,
William Hughes.

52, Cartwright Gardens, W.C.1 (late 50, Bellemy-road, Southampton), October 21, 1919.

THERMIONIC VALVES.

To the Editor of Engineering.

Sir,—In your report of the British Association given in Engineering of October 10, there are two points to which, in justice to those concerned, attention should be drawn.

The first point,* in the order in which they appear, is that the stated output of half a million thermionic valves per annum represents, not the contribution of the Osram-Robertson works, though theirs was actually the largest share both in development and in production, but the total rate of production in this country. By the time of the armistice practically every lamp manufacturer in the country was making an effective contribution to this total. This was the response of an already overtaxed industry to a demand made upon it less than a year before.

Secondly, the tests and investigations to which general reference was made were those carried out mainly in the laboratories and test rooms of the service experimental establishments and in certain university laboratories, and were undertaken because the high standard of reliability set by service requirements made it desirable to possess the fullest possible knowledge of the properties and behaviour of these instruments. Only in the later stages did the manufacturers carry out much work of this kind.

It was in no way my intention to enlarge on the merits of any particular firm. Such a course would have been scarcely suitable to the occasion, and certainly unwelcome to the firm in question. I much regret that my remarks should have been so worded as to give a false impression to the writer of your report.

Yours faithfully,
B. S. Gossling,
Research Laboratories of the General Electric Company, London.

Temporary Offices, Osram-Robertson Lamp Works, Brook Green, Hammersmith, London, W. 6, October 20, 1919.

Institution of Naval Architects: Scholarship Awards.—The council have awarded the Cammell Laird scholarship in naval architecture (150*l.* per annum for three years) to Mr. H. J. R. Biles, of the Fairfield Shipbuilding and Engineering Company, Limited, and the Parsons scholarship in marine engineering (150*l.* per annum for three years) to Mr. W. G. Simmonds, of Chatham Dockyard.

Lighting for Protection.—Remarkable testimony to the value of flood lighting for protective purposes was provided during the recent railway strike by the use of British Thomson-Houston Company's projectors at Lots-road power station. These projectors are mounted on tripod stands and can be swivelled both horizontally and vertically. Each projector is equipped with a 1,000-watt Mazda half-watt type lamp. It was found that two or three watchmen, each having under his control a British Thomson-Houston floodlight projector, could maintain close observation over the whole area from which interruption was likely to proceed. The slightest movement of a twig or piece of paper could be clearly seen at a distance of 300 ft. or 400 ft., and it would have been quite impossible for any ill-intentioned person to have approached the power station unobserved. The projectors can be rapidly installed in case of emergency, the only preliminary necessary being the provision of leads from the nearest available source of energy.

The Parsons Marine Steam Turbine Company, Limited.—The report and accounts of this company for the year ended June 30, 1919, state that since the outbreak of war, the company's works have been continuously employed in their full capacity in the construction of propelling machinery for a battleship, for cruisers, torpedo-boat destroyers, patrol boats and merchant vessels; the total horse-power of these installations completed during the period of the war amounted to 664,900. In addition, mechanical gearing was constructed for other marine engineering companies, for cruisers, flotilla leaders, torpedo-boat destroyers, passenger and cargo vessels, the total horse-power amounting to 721,100. Further, in addition to the foregoing, the work of cutting teeth in gear wheels and pinions was completed for other marine engineering companies for cruisers, torpedo-boat destroyers, patrol boats, a seaplane carrier, tenders, submarines, passenger and cargo vessels, having a total of 1,578,200 h.p. The application of geared turbines to marine propulsion, on the system initiated by the company, continues to make great progress; during the period of the war, the fastest cruisers, flotilla leaders, and torpedo-boat destroyers, were fitted with geared turbines; at present, many passenger and cargo-carrying vessels are being constructed to be fitted with geared turbines.

* See report of Mr. B. S. Gossling's remarks on page 470, middle column.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Iron and Steel.—But for the moulders' strike the staple trades would be making satisfactory headway. The continued dearth of castings and moulds is holding up the heavy engineering sections, and has a serious reflex on the lighter branches. Engineering employers, by co-operation, are doing their utmost to hold off the worst effects of this labour deadlock, but have been obliged this week to discharge a considerable number of men in dependent trades. Sheffield's unemployed total of 19,000 closely approximates the highest level reached during the recent railway strike. It is feared this figure will increase rather than diminish if an early settlement is not reached. Apart from this setback, increased activity is seen in practically every branch of manufacture. Export inquiries for tools and manufacturing material are more numerous than since the end of the war, and orders for special steel, rolled and hammered mild steel, railway tyres, axles, automobile parts and electrical machinery are arriving in increasing numbers. The progress of municipal housing schemes, though slow, is responsible for an improved demand for light castings. Sheffield steel makers are benefiting from the effect on foreign markets of the United States reduced output, due to the continuance of the strike epidemic in that country. Rolling mills and forges are maintaining much more even conditions. In fact, some of the medium-sized mills which are utilised for contract work and are specialising in motor-car steel and axles are working overtime to keep pace with the increased demand, and are considering the advisability of reintroducing the three shift system and thus ensuring continuous output. The Advisory Committee working in conjunction with the Sheffield Chamber of Commerce are taking special precautions to combat trade piracy respecting the use by American and German manufacturers of registered marks. That there is call for special alertness in this direction is shown by the fact that the latest shipments of German steel contain goods bearing inaccurate and misleading descriptions such as "Warranted Sheffield make." The crucible steel trade is only moderately employed. The demand for electric steel is met by furnaces working half time. In raw material the market is more active, and the demand for certain classes of iron is improving, except in the case of foundry iron, where consumption has been reduced to a minimum through the moulders' strike. Now that many furnaces have ceased producing basic pig-iron, quotations have been revised as follows:—Lincolnshire forge, 8*l.* 12*s.* 6*d.*; Lincolnshire basic, 8*l.* 17*s.* 6*d.*; Derbyshire forge, 8*l.* 7*s.* 6*d.*; Derbyshire foundry, 9*l.* 2*s.* 6*d.*; Derbyshire basic, 8*l.* 15*s.*; finished iron, common bars, 22*l.* 10*s.*; steel billets, Bessemer acid, 19*l.* 2*s.* 6*d.*; Siemens, 19*l.* 12*s.* 6*d.*; hard basic, 16*l.* 10*s.*; soft basic, 15*l.* 5*s.*; steel hoops, 26*l.*

South Yorkshire Coal Trade.—The great scarcity of empty wagons is causing general complaint and is increasing the difficulties of collieries and merchants. The demand in practically every section is still in excess of the supply, and only in those cases where production is deterred by strike influences is much progress being made with the rebuilding of emergency stocks. Inland works are taking the bulk of the output of steam fuels on contract account, and are pressing for increased deliveries. The demand for slacks is maintained at a high level. Supplies are more abundant than recently, and prices remain at the maximum. Business in house coal is more than ever confined to meeting the special requirements of the Coal Controller. Areas where the shortage is acute are receiving special attention, and steps have been taken to ensure adequate deliveries to food-producing trades, electricity and gas undertakings, and the railways. Quotations:—Best branch handpicked, 33*s.* to 34*s.*; Barnsley best Silkstone, 33*s.* to 33*s.* 6*d.*; Derbyshire best brights, 31*s.* to 32*s.*; Derbyshire house coal, 28*s.* 6*d.* to 29*s.*; Derbyshire best large nuts, 28*s.* 6*d.* to 29*s.* 6*d.*; Derbyshire small nuts, 27*s.* 6*d.* to 28*s.* 6*d.*; Yorkshire hards, 28*s.* 6*d.* to 29*s.* 6*d.*; Derbyshire hards, 28*s.* 6*d.* to 29*s.* 6*d.*; best slacks, 24*s.* to 25*s.* 6*d.*; nutty, 23*s.* to 24*s.*; smalls, 19*s.* to 20*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

Middlesbrough, Wednesday.

Hematite Iron.—Supply of East Coast hematite is now very ample. A moderate home business is doing, and a few sales to customers abroad are reported, but the adverse rates of exchange in several European countries have a deterrent influence upon foreign trade. Expansion of export trade is, however, looked for. Nos. 1, 2 and 3 are 200*s.* for home use and 205*s.* for shipment abroad, and No. 1 is 202*s.* 6*d.* for home purposes and 207*s.* 6*d.* for export.

The Cleveland Iron Trade.—Continued great scarcity of Cleveland foundry pig-iron is the dominating feature of the iron trade. Foundry is the quality in chief demand, and as there seems little likelihood of the output of that grade being increased to any material extent for some little time, the furnaces working very irregularly, after the recent enforced stoppage, makers are endeavouring to meet the situation by insisting that all orders for foundry iron must be accompanied by orders for equal quantities of forge kind. As the latter, however, is unsuitable for certain purposes, few customers are inclined to conform to the stipulation with the result that business is not on an extensive scale. Ironfounders are keen to receive deliveries of pig-iron in fulfilment of running contracts so as to build up stocks, even though their works are closed. The effects of the iron-

founders' strike have thus, as yet, been almost imperceptible, but a continuance of the dispute will probably ease the situation, and in that case more iron should be available to meet the heavy Continental demand, and seeing that export licences are no longer very difficult to secure, considerable expansion of foreign trade should be experienced. For home consumption, No. 3 g.m.b. Cleveland pig-iron, No. 4 foundry and No. 4 forge, all stand at 160*s.*, and No. 1 is 164*s.*; whilst export prices are 5*s.* above these rates.

Foreign Ore.—New business in foreign ore is still practically nil, but imports on running contracts show great improvement, and the unloadings to date this month have become larger than those for the corresponding part of September. Rubio, of 50 per cent. quality is, nominally, 53*s. c.i.f.* Tees, and the freight Bilbao-Middlesbrough remains at 24*s.* 6*d.*

Coke.—There is heavy demand for coke. Distribution of the good supply continues to be hampered by shortage of trucks. Average blast-furnace coke is 48*s.* at the ovens, and low phosphorus sort is 49*s.* 6*d.* at the ovens.

Manufactured Iron and Steel.—The finished iron and steel works are once more working under high pressure. The recent strikes have been responsible for deliveries, under current contracts, falling into arrear, and effort is now being made to overtake them. Good home and foreign inquiry is reported, and prospects are rather encouraging. Steel packing bars have risen 1*l.* and further advance in sheets is reported. Common iron bars are 22*l.*; marked bars, 25*l.*; steel packing parallel bars, 16*l.*; steel packing tapered bars, 20*l.*; steel ship, bridge and tank plates, 18*l.* 5*s.*; steel boiler plates, 21*l.* 10*s.*; steel angles, 17*l.* 15*s.*; steel joists, 17*l.* 10*s.*; heavy sections of steel rails, 16*l.* 10*s.*; black sheets, 26*l.*; and galvanised sheets up to 34*l.* Export prices are still matter of individual negotiation, but may be given as a little above the foregoing rates, which rule home trade.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—Owing to the strike of the bricklayers the steel trade has quietened down, and the position with which the various consumers is faced is rather serious. Shipbuilders are finding great difficulty in securing supplies of plates, and a continuance of the present conditions will very seriously affect the output of new tonnage, as many shipyard workers will shortly be out of work. A conference between representatives of the steel companies and the Bricklayers' Union was held in Glasgow at the end of last week, when the masters offered to discuss the question of wages on condition that the men returned to work at once and that they would be willing to resume overtime as usual. These conditions were placed before the men and a ballot was taken, with the result that they were rejected. The position is now very serious, as quite a large number of men in other trades have also been thrown idle, and the prospects of a settlement are far from bright. Meantime there is an ever-increasing demand for steel, with ship plates almost at a premium. Sections are not too active, but makers of black sheets report a good turn of business even at the recently advanced rates, and order books represent a large amount of work. The shipping side of the trade is fair, and there is quite a good inquiry, but with the latest turn affairs have taken the prospect of improvement in export is further away than ever. Prices all round are firm and unchanged.

Malleable Iron Trade.—No change falls to be reported in the malleable iron trade of the West of Scotland, and makers continue to be very busy. Bookings have lately been on a large scale, as bar iron has been in much request, and inquiries point to active conditions ruling for the next month or two. Most of the present business is on home account. Prices are steady and strong.

Scotch Pig-Iron Trade.—At the present time there is quite a good business passing in the Scotch pig-iron trade, and a steady demand exists for most kinds of iron, particularly for the higher grades. Inquiries both for the home market and for export lots are showing signs of increasing, and a fairly satisfactory trade is going through. Hematite is more plentiful owing to the falling-off in requirements at the local steel works, and when business is again in full swing there should be good supplies available for the steel makers. Outputs of iron are beginning to show an improvement and an increased tonnage would be much welcomed by all connected with the trade.

Scotch Coal Trade.—Conditions in the Scotch coal trade are active, and a heavy demand exists for supplies of most qualities. Large orders are general for the many industrial establishments in the West of Scotland, and the stock on hand when the recent railway workers' strike took place and caused a stoppage of deliveries are again being made up. This is, of course, causing a heavy pressure at the pits, but every endeavour is being made to meet requirements all round. Shipping is improving, and some good inquiries are at present in the market. The demand from householders has increased owing to the seasonable weather, and large deliveries are being made to the various gas concerns.

West of Scotland Iron and Steel Institute.—The opening meeting of the twenty-seventh session of the West of Scotland Iron and Steel Institute took place last Friday, in the Royal Technical College, Glasgow. Mr. M. L. Simpson, president, occupied the chair, and in the course of an interesting address he referred to the problems of reconstruction with which the country was now faced. He urged a united effort on the part of all classes, and in deploring the strike weapon, so freely used since the armistice, he put in a plea for a full and frank discussion of wages and conditions before workers ceased operations.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Local Markets.—The coal market has developed increased easiness on account of a shortage of tonnage and the slowness of tipping operations, and, in consequence, a diminution in the export capacity of the various ports. To-day there were 275 vessels in the Cardiff, Penarth, Barry and Newport docks, which is the lowest total for some months past. Actual business is slow and principally confined to deals for quick loading. Prices, though easy, are irregular and dependent on the individual circumstances of sellers. Some collieries are still asking up to 30*s.* for the better quality large coals, but other undertakings are in need of empty wagons and are ready to make substantial sacrifices to buyers able to arrange quick shipment. Best Admiralty and Monmouthshire large sorts are obtainable down to 72*s.* 6*d.*, and ordinary descriptions for 67*s.* 6*d.* Dry large is also easier and available at 72*s.* 6*d.* for best and 67*s.* 6*d.* for the cheaper grades. Steam smalls, too, are cheaper, and the best descriptions are worth no more than 37*s.* 6*d.*, with ordinary cargo smalls plentiful from 35*s.*, and inferiors from 35*s.* Bituminous coals are relatively stronger than other grades, as a large proportion of outputs are absorbed by home consumers. No. 2 Rhondda large are round 67*s.* 6*d.* and throughs 57*s.* 6*d.* Rumours of a revision of the Government restrictions on the export trade have given satisfaction. It is anticipated that, after the home demands have been met, merchants will be free to export the surplus abroad subject to the approval of a representative committee consisting of colliery owners and exporters.

Iron and Steel Trades.—Generally conditions in the iron and steel trades are unchanged. Makers, in the majority of cases, are well supplied with orders till the end of the year, and consequently new business is quiet. Prices generally are firm, especially for tin plates and galvanised sheets. Tin plates have reached 40*s.* per box for the basis box and, as the inquiry is active, manufacturers are holding for an advance. An active demand also exists for galvanised sheets in cases and bundles. Fairly large quantities of 24-gauge corrugated bundles have been sold for shipment to South Africa at 34*l.* f.o.b., and the Far East is inquiring for thin gauges at from 44*l.* to 48*l.*, according to destination. Steel bars are quoted at 14*l.* per ton for prompt delivery, but for forward business sheet and tin-plate bars command up to 14*l.* 15*s.*

Sharp Rise in Freights.—There has been a sharp rise in outward freights during the past week. Tonnage offers are not sufficient to meet the demand, and Genoa has been done at 72*s.* 6*d.*, which represents an increase of 20*s.* on the top rate in September; Malta at 60*s.*, an increase of 17*s.* 6*d.*; Port Said 65*s.*, an advance of 15*s.*; and Gibraltar at 52*s.* 6*d.*, an increase of 7*s.* Spanish and Portuguese rates have also substantially increased, and French rates are on a par with the highest levels reached this year.

CATALOGUES FOR TRIESTE.—H.M. Consul-General, Trieste, desires to receive trade catalogues for exhibition in the Consulate, with extra copies for distribution. Catalogues should be sent direct to the British Consul-General, Trieste.

THE METAL WORKERS' FEDERATION.—A national Conference between metal manufacturers and metal merchants took place a few days ago in London. Well-known men in the metal industry, from all over the kingdom, came to represent the National Federation of Iron and Steel Manufacturers and the British Federation of Iron, Steel, Tin-plate and Metal Merchants. Mr. John Craig, Mr. E. Steer, Mr. H. C. Bond and Mr. Borough Hopkins were the principal speakers for the manufacturers, Mr. Craig occupying the chair in the absence of Mr. Scobie Smith. The merchants were represented chiefly by Sir Johnstone Wallace, Sir Christopher Needham, Mr. John Hall, Mr. H. J. Skelton and Mr. J. Gray Buchanan. The meeting was called into being by an earnest desire on the part of the merchants, who for the most part distribute the goods produced by the manufacturers, to extend a friendly and sincere offer of co-operation with the manufacturers, in order to co-ordinate their policy and by combined work endeavour to increase our export trade. Only general principles were touched upon at this first meeting, Mr. H. J. Skelton, in particular, giving a very able exposition of the part played in industry by the merchant and drawing the attention of those present to the fact that the manufacturers in most cases had neither the facilities nor the *personnel* to cope with the numerous problems concerning banking, exchange, freight and insurances which were constantly confronting merchants who, by their training and experience, were peculiarly well suited to handle them Hopes were expressed by the Merchants' Federation that agreements might be arrived at with the manufacturers whereby the latter would devote their energies entirely to the problems of labour, plant and production, and not sap their thoughts and resources by trying to do direct trade with consumers. The British Merchants, a wonderful distributing organisation, having agencies all over the globe, were ready to handle the manufacturers' products, pay promptly for them, and distribute them to all quarters of the earth. The manufacturers requested the merchants to draw up for their consideration a definite proposal for co-operation, and this is now being taken in hand by the Merchants' Federation.

NOTICES OF MEETINGS.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, October 24, at 6 p.m., at the Institution of Civil Engineers, Great George-street, Westminster. Address by the president, Mr. Edward Hopkinson, D.Sc., M.P.

THE PHYSICAL SOCIETY OF LONDON.—Friday, October 24, at 5 p.m., at the Imperial College of Science, Imperial Institute-road, South Kensington, S.W. (1) "The Effect of Pressure and Temperature on a Meter for Mensuring the Rate of Flow of a Gas," by Mr. N. W. McLachlan, D.Sc., M.I.E.E. (of the National Physical Laboratory); (2) "A Cheap and Simple Micro-Balance," by Mr. J. H. Shaxby, B.Sc. (of University College of South Wales, Cardiff); (3) "The Resolution of a Curve into a Number of Exponential Components," by Mr. J. W. T. Walsh, M.A., M.Sc. (of the National Physical Laboratory).

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, October 24, at 7.30 p.m., at 39, Victoria-street, Westminster, Lecturette by Captain Stanley W. Thorpe, Chief Officer, Kodak Fire Brigade, on "Fire Prevention and Protection in Factories and Workshops." Friday, October 31, at 7.30 p.m., at 39, Victoria-street, Social Evening. Recently-elected members specially invited.

THE STAFFORDSHIRE IRON AND STEEL INSTITUTE.—Saturday, October 25, at the Education Offices, St. James'-road, Dudley, when a paper on "The Fuel Question" will be read by Mr. W. Macfarlane, of Wednesbury. Preceding the paper, the president (Mr. Carrington) will give a short address.

THE MANCHESTER ASSOCIATION OF ENGINEERS.—Saturday evening, October 25, at the Grand Hotel, Aytoun-street. The evening will be reserved for a discussion on "Prices and Conditions for the Supply of Electric Power to Works." From the point of view of the purchaser, by Mr. William Cramp, D.Sc., M.I.E.E.; from the point of view of the supplier, by Mr. Julius Frith, M.Sc., M.I.E.E. The chair will be taken at 7 p.m.

THE AERONAUTICAL SOCIETY OF GREAT BRITAIN.—Wednesday, October 29, at 8 p.m., the first meeting of the fifty-fifth session of the Royal Aeronautical Society will be held in the Theatre of the Royal Society of Arts, John-street, Adelphi, London, W.C. Sir Horace Darwin, K.B.E., M.A., F.R.S., will give a lecture on "The Static Head Turn Indicator for Aeroplanes." The chair will be taken by Brigadier-General R. K. Bagnall Wild, C.M.G., C.B.E., R.E.

THE INSTITUTION OF LOCOMOTIVE ENGINEERS, LONDON.—Wednesday, October 29, at 7 p.m., at Caxton Hall, Westminster, a paper will be read on "An Approximate Method of Estimating Superheat and Boiler Output and Evaporative Efficiency," by W. Rowland, Manchester. The paper will also be read at the College of Technology, Manchester, on November 7; and at the Philosophical Hall, Leeds, on November 11.

AMERICAN SHIPBUILDING FOR SWEDEN.—Delegates of the Swedish-American Line are reported to be in the United States in an endeavour to place contracts for at least two passenger steamships of the "Stockholm" type, says *International Marine Engineering*, which adds that the American representatives of the company are Messrs. Furness, Withy and Co., 34, Whitehall-street, New York.

THE WIRELESS SOCIETY OF LONDON.—A general meeting of the Wireless Society of London will take place at the Institution of Civil Engineers, St. George-street, Westminster, on Tuesday, October 28, at 6 p.m. The meeting will cover many items of interest to members and prospective members, and a good attendance is hoped for. After five years of inactivity due to the war the society is again busy in the interests of experimenters and amateurs interested in wireless telegraphy, and this first general meeting will be an important one. We are told that there will be an exhibition of wireless apparatus from several different sources, and this in itself will add to the value of the meeting. Particulars of the society can be obtained from the Hon. Secretary, Mr. Leslie McMichael, 30, West End Lane, West Hampstead.

MAXIMUM PRICES OF PETROL.—The Board of Trade have issued an Order fixing the following maximum wholesale prices of motor spirit in cans in lieu of the prices fixed in the Order of October 1, 1919:—

	Per Gallon.
	s. *d.*
Aviation	3 0
Special boiling points	2 11½
No. 1	2 8
No. 3	2 6

For delivery to commercial consumers (not for re-sale) in steel barrels, 1*d.* per gallon less than can price, and for delivery in bulk to commercial consumers (not for re-sale), 1½*d.* less than can price. One penny per gallon to be added to all above prices when sold for delivery in Scotland or Ireland. The maximum price at which motor spirit may be sold by retail shall be the delivered price per gallon to the retailer, with an addition of 4½*d.* per gallon. Quantities less than a gallon shall be sold at a price proportionate to that charged per gallon. Where motor spirit is delivered by a retailer to a purchaser at any place other than the retailer's place of business, an extra charge at the rate of 1*d.* for a gallon or for any part of a gallon may be added to the price permitted by this Order.

CONSTRUCTION OF THE U.S. TORPEDO-BOAT DESTROYER "WARD."

(*For Description, see Page* 543.)

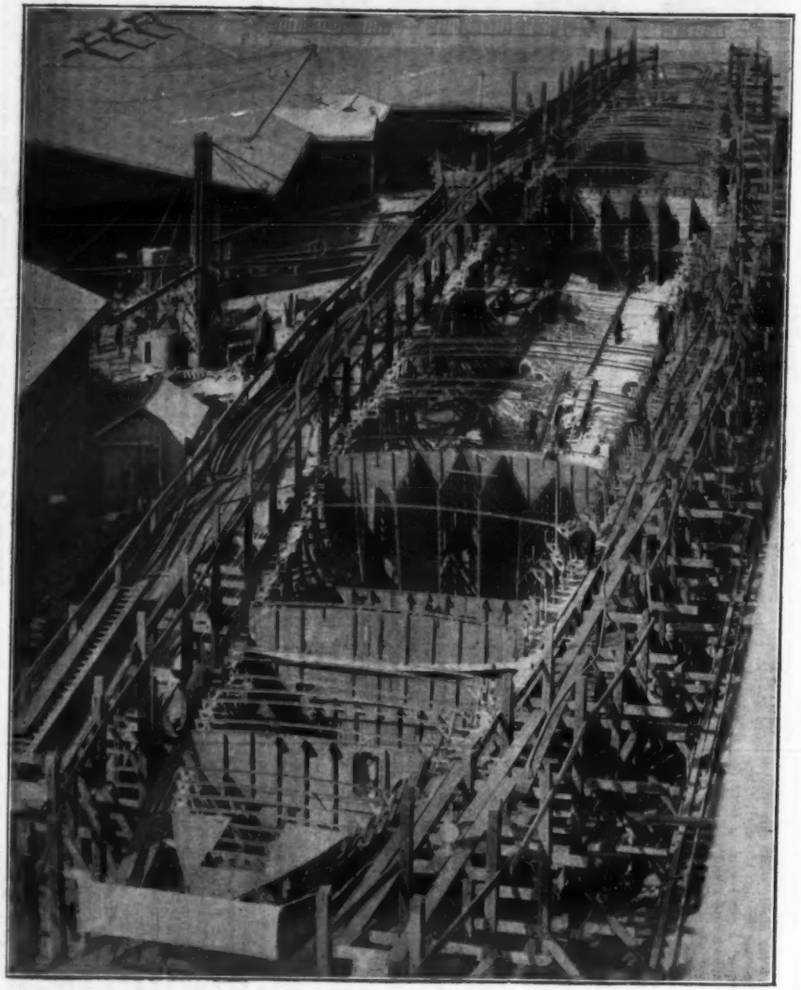


FIG. 4. ONE DAY ON THE SLIP, MAY 16, 1918.

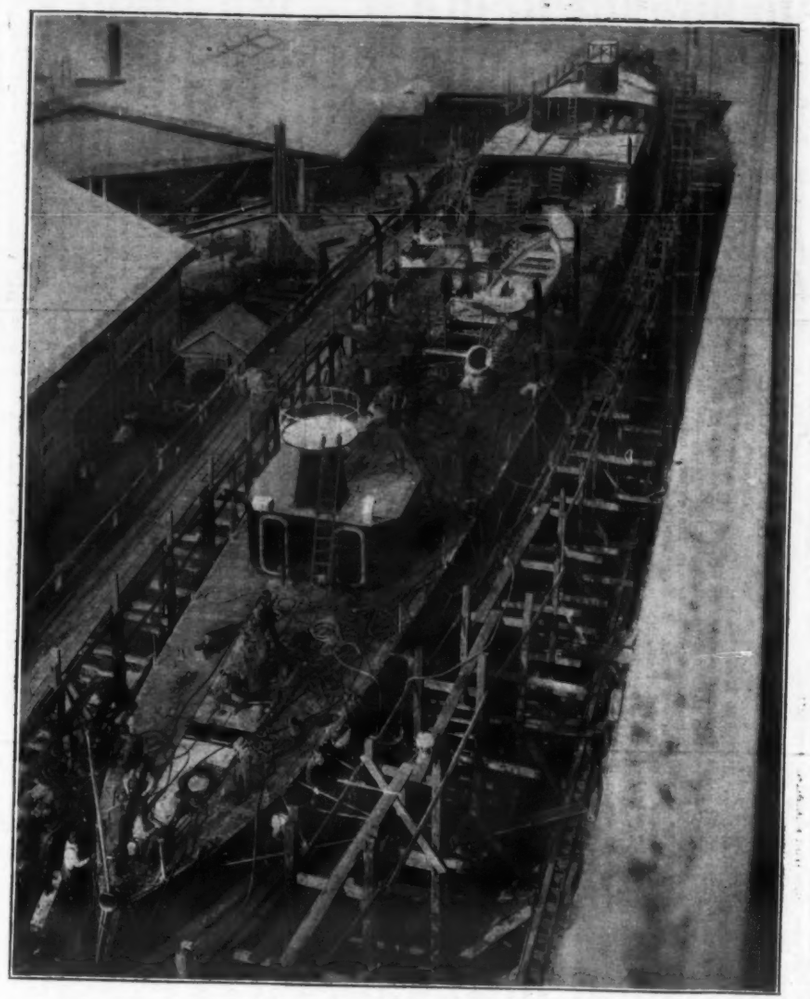
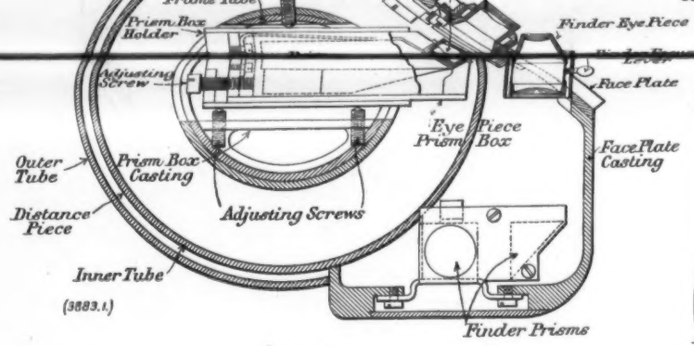
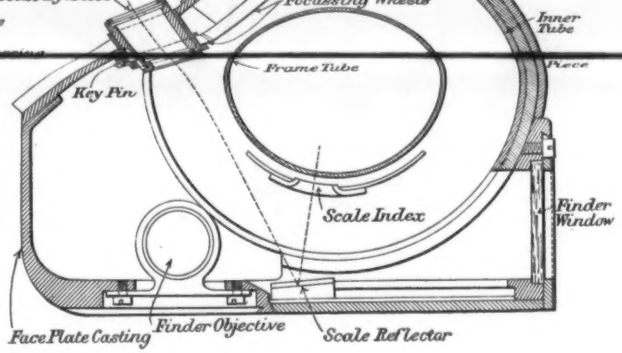


FIG. 5. FIFTEEN DAYS ON THE SLIP, MAY 30, 1918.

CORROSION BY LEAKAGE FROM AN ELECTRIC FUSE-BOARD.—A case of corrosion by current leakage from a fuse board of the Barrow-in-Furness Electricity Department is briefly discussed by W. Stewart Patterson in the Journal of the Society of Chemical Industry of September 15. The board had been in use for four years on a 220-volt circuit, when a fire occurred at the back of the board owing to the insulation being eaten away. The wall behind the board was found covered with a greyish deposit, and the bricks had turned soft and crumbly to a depth of at least 1 in.; some of the deposit had settled on the negative pole whilst the positive terminal was free from it. The deposit looked like soda and was found to contain about 60 per cent. of sodium carbonate, 5·5 per cent. of caustic soda and 34 per cent. of water. Free soda was also found in the soft bricks, and in the mortar (made apparently with sea sand). The explanation offered is that moisture penetrated into the brick and provided a leakage path from the live pole to the earth; the current electrolysed the brick, liberated and removed the soda in it, and the brick was destroyed partly by the electrolysis and partly by the action of the soda. The case is represented as peculiar, and it is mentioned that no similar case seems to have been observed. But the nature of the insulating material is not stated, and the percentages of alkali salts found in the bricks and mortar, considered to be not uncommon, may be unusual.


Prism Box Holder
Adjusting Screw
Eye Piece Prism Box
Face Plate
Face Plate Casting
Outer Tube
Prism Box Casting
Distance Piece
Adjusting Screws
Inner Tube
Finder Prisms


Key Pin
Frame Tube
Scale Index
Finder Window
Face Plate Casting
Finder Objective
Scale Reflector

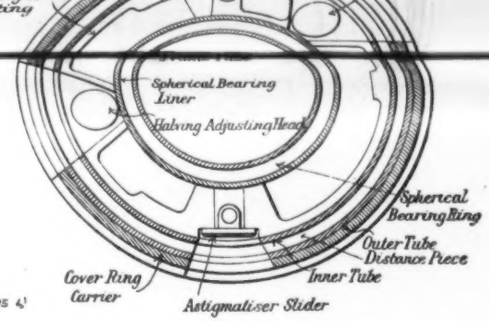

Spherical Bearing Liner
Halving Adjusting Head
Spherical Bearing Ring
Outer Tube
Distance Piece
Inner Tube
Cover Ring Carrier
Astigmatiser Slider

Fig.41.

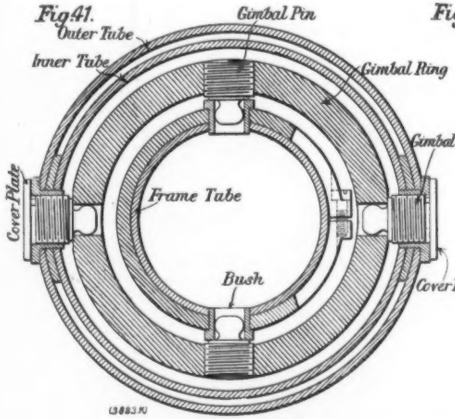
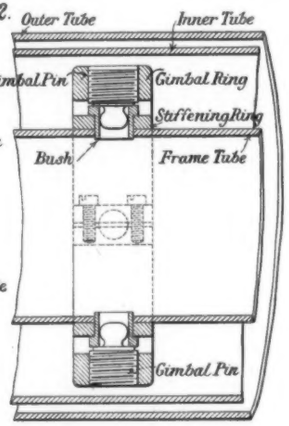

Outer Tube
Gimbal Pin
Inner Tube
Gimbal Ring
Gimbal Pin
Cover Plate
Frame Tube
Bush
Cover Plate

Fig.42.


Outer Tube
Inner Tube
Gimbal Pin
Gimbal Ring
Stiffening Ring
Bush
Frame Tube
Gimbal Pin

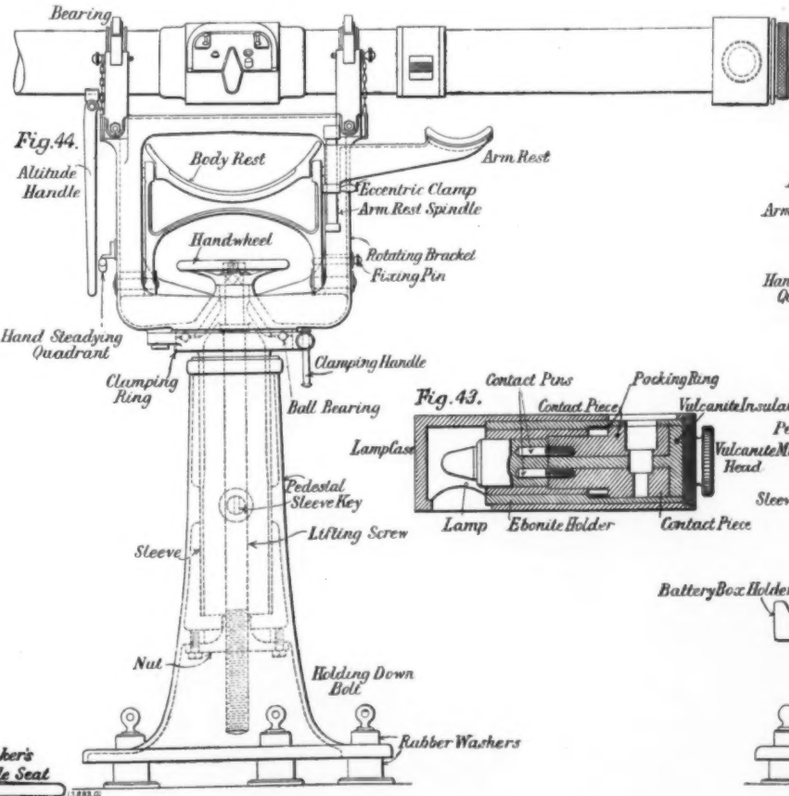

Bearing
Fig.44.
Body Rest
Arm Rest
Altitude Handle
Eccentric Clamp
Arm Rest Spindle
Handwheel
Rotating Bracket Fixing Pin
Hand Steadying Quadrant
Clamping Handle
Clamping Ring
Ball Bearing
Pedestal
Sleeve Key
Lifting Screw
Sleeve
Nut
Holding Down Bolt
Rubber Washers

Fig.43.
Contact Pins
Packing Ring
Contact Piece
Vulcanite Insulator
Lamp Glass
Vulcanite Milled Head
Lamp
Ebonite Holder
Contact Piece

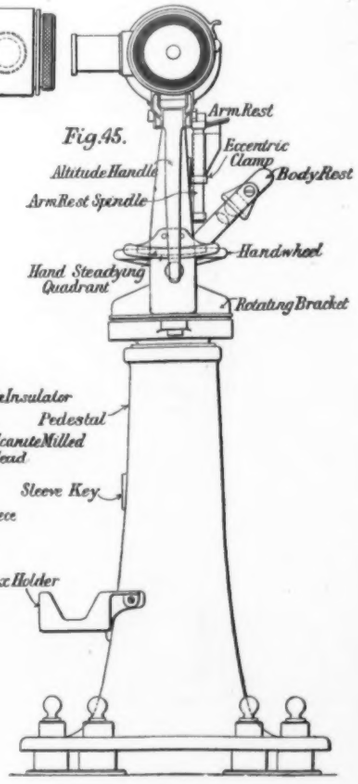
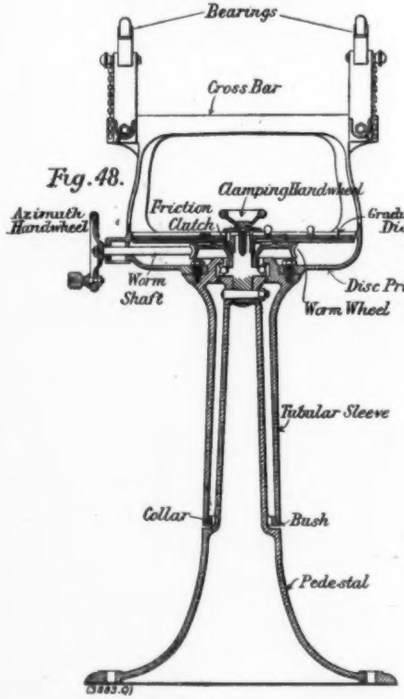
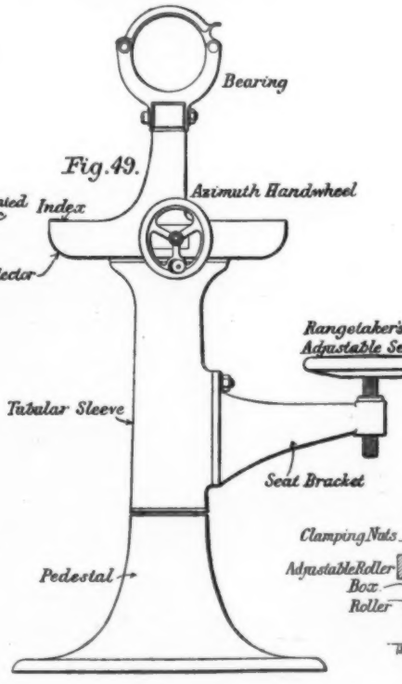


Fig.45.
Arm Rest
Eccentric Clamp
Altitude Handle
Body Rest
Arm Rest Spindle
Handwheel
Hand Steadying Quadrant
Rotating Bracket
Pedestal
Sleeve Key
Battery Box Holder


Bearings
Cross Bar
Fig.48.
Clamping Handwheel
Azimuth Handwheel
Friction Clutch
Graduated Disc
Worm Shaft
Disc Protector
Worm Wheel
Tubular Sleeve
Collar
Bush
Pedestal


Bearing
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Rangetaker's Adjustable Seat
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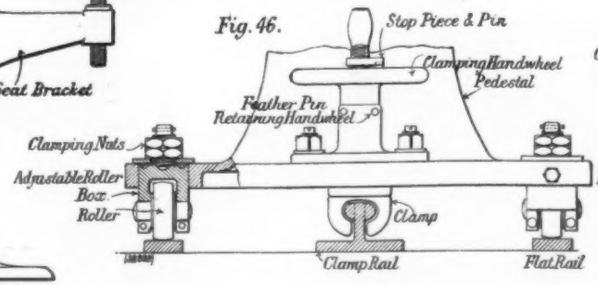
Fig.46.
Stop Piece & Pin
Clamping Handwheel
Pedestal
Feather Pin
Retaining Handwheel
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Adjustable Roller Box
Roller
Clamp
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Flat Rail

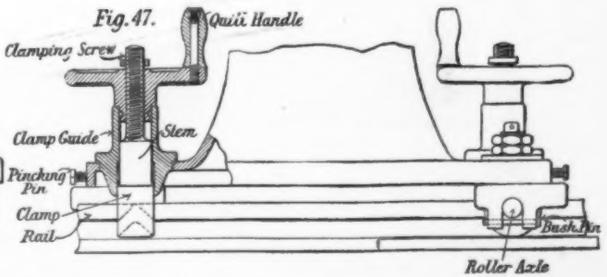
Fig.47.
Quill Handle
Clamping Screw
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Bush Pin
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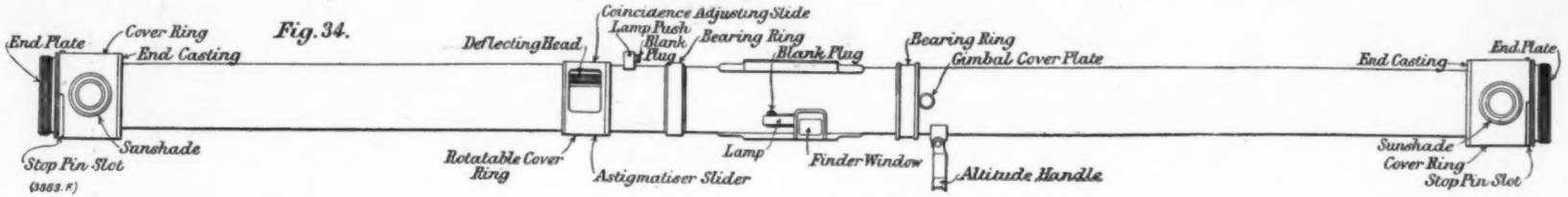
NAVAL AND FORTRESS RANGEFINDERS AND MOUNTINGS.

CONSTRUCTED BY MESSRS. BARR AND STROUD, LIMITED, ENGINEERS, ANNIESLAND, GLASGOW.

(For Description, see Page 536..)

Fig. 34.



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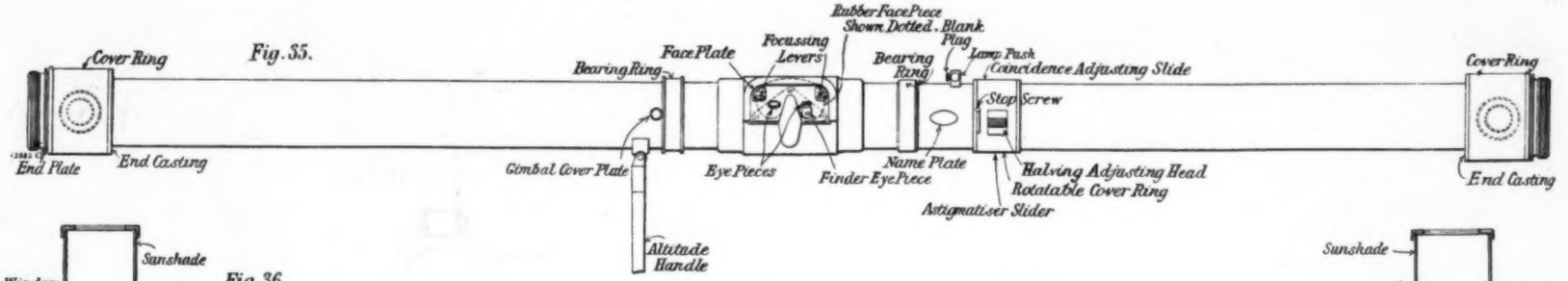

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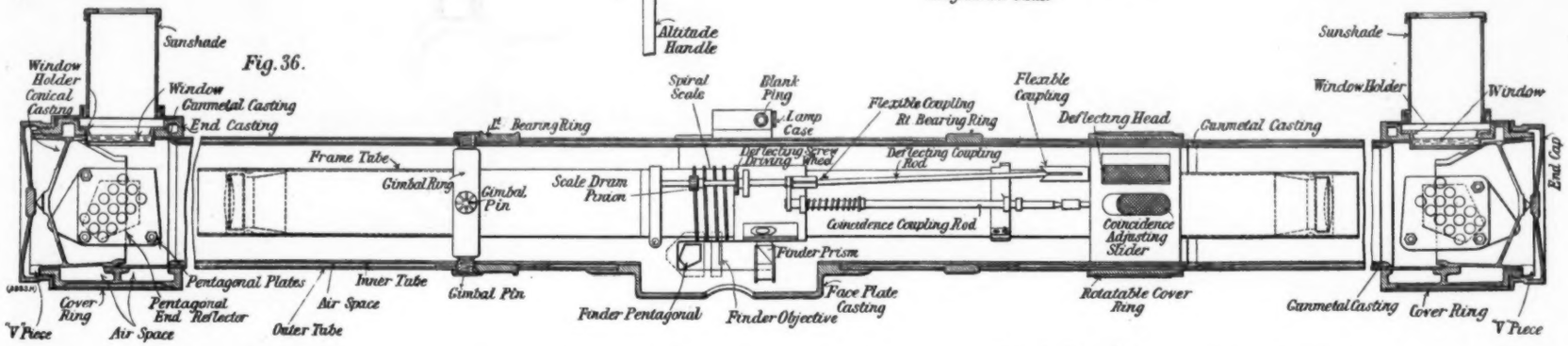

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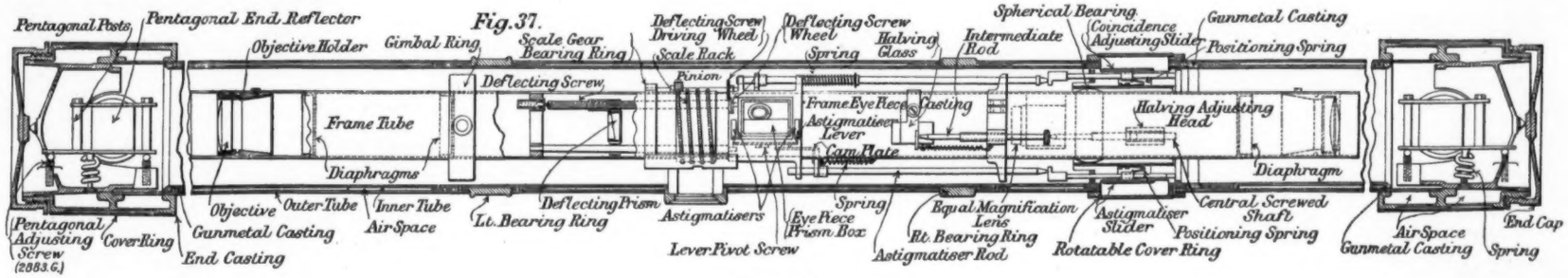

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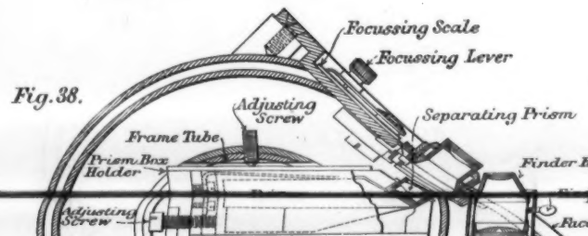

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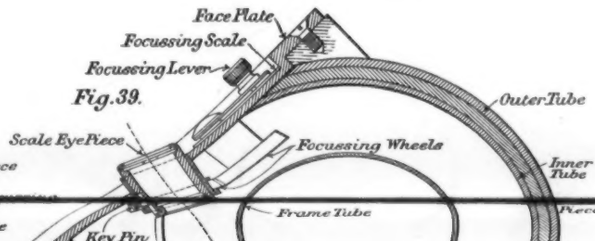
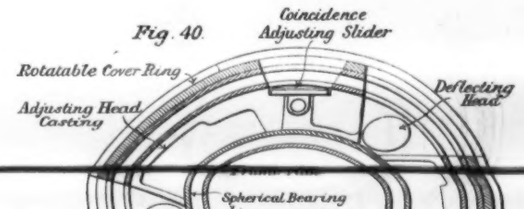


Fig. 40.



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In view of the restrictions still imposed by the Government on the importation of paper and the consequent shortage of supplies, Newsagents will not have copies for chance customers: therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 551.

ENGINEERING.

FRIDAY, OCTOBER 24, 1919.

LABOUR AND LICENSE.

CERTAIN individuals, prominent and otherwise, are never satisfied unless by some paradox or reconciled incongruity they achieve notice. This is all very well so long as their verbal gymnastics and eloquence are confined to intangible things or to subjects whose very nature allows great latitude in debate. It is otherwise where definite matters of a practical character are in question, for while there may be difference in precise detail the underlying principles are fixed. When the attempt is made to apply paradox to such subjects it may result in disaster, in commercial discomfiture or in national trouble of a large order, if the publicist is a man of prominence. Standing on one's head to view the universe from a different angle may be tolerated when it affects one individual only; standing the universe upside down to see how it looks might conceivably mean the extinction of the human species to please the idiosyncracy of a single person. No one need fear legitimate evolution in any direction; all reasonable beings have cause to fear alteration not in line with previous experience. We are so constituted that a single step gives anxious consideration, and may be viewed for that matter with trepidation. A whole series of steps at a bound or a sweeping movement forward without visible steps is apt to cause general panic.

The industrial critic who believes that specialisation and standardisation have put an end to skill of craft, who cannot clearly appreciate how trade skill can exist in view of sectionalised process, and who discounts its value may be amusing to the engineer, but he not merely exists but influences others. "Artisan skill, so termed, is a fraud," was a statement recently made; it is difficult to assess the intangible and equally so to produce the required proof that such a remark is a perversion of the real facts. There is sufficient foundation to make the statement plausible; the reverse case is much harder to put in view of dilution and the feminine invasion of industry. This is one end of the scale, the other extreme has led to the notorious happenings of recent weeks, whereby a small section of the community whose skill is small but whose place in the scheme of things is difficult to fill at a moment's notice have held the community to ransom. So long as we are civilised it will be possible for one tooth in the vast train of years to put everything else out of running. Like the small detail for want of which the most complex mechanism is inert material, a relatively small body of men can for their own purpose involve much cruelty and vast inconvenience to a great mass of mankind. The power of tiny minorities to effect the wreckage of a complex scheme of transport or the bulk of a large organisation is undoubted: any co-ordinated body of men of a given activity can paralyse for a short time the need of a whole community. The act is justifiable only if no other means of discussion or argument will serve. The over-riding principle of democracy is that the majority rule and that all are servants of the rest. It is ignorance which disavows responsibility and barbarism which holds the world to ransom for small grievances which can be collectively adjusted. Turning the universe upside down will, by example, penalise in turn each section who, having had its turn at the process, finds it less desirable when others by force of example find it easy to cause confusion. Redressing grievance by human sacrifice is the extreme end of such practice, and so long as governance is submitted to by the majority, it is expected that, where the service is essential, strong measures will be taken which will inevitably have the wholehearted support of the mass of mankind.

Disorder is ruin, and it cannot be contended at this date that opportunity to ventilate and redress grievance is withheld. If every man or particular section is to be for themselves against the rest, then let us all return to the stone age where the argument was a club and main strength the only ethic, let us alternately starve and be annihilated by disease, and organised in tribal bands seek the wilderness again. On principle no single class can dictate terms to the rest; civilisation must be co-operative. Wrong in the past does not excuse reversal of its practitioners in the present, and no tyranny can be more galling than that dictated by ignorance. The more we are civilised the more we are dependent. If the past decade has taught anything it is that by small readjustments we can be less dependent and more self-sufficient. It is a case of limiting wants and lowering standards and, moreover, although skill is real, the limited skill needed to conduct essential services can be extemporised granted a sufficient reserve of really skilled units. That is the lesson of dilution, substitution and sectionalised process: the improvisation taught by war can be more generally applied if necessary, always granted the highly skilled minority. Only under civilised conditions can skill of this higher type be raised. A return to greater simplicity means that the expert who undertakes more general work must inevitably be less expert. If, for example, he has to be a self-provider, the making of the essentials of life will leave no time for intellectual pursuits or specialising. The spirit of sacrifice for a common end appears to be falling to a very low ebb, the ideal of service becoming less recognised. The complexities in a period of transition afford unique opportunities for wrecking, and some are illadvised enough to press a temporary advantage to its uttermost limit.

It would appear that might is still right in certain directions; the fact of power involving responsibility and recognition restraint seems out of fashion. Duty should come before payment and discipline be precedent to relaxation. These are principles which do not affect the conscience of certain bodies of men. Having found the strength due to unity, it is being exercised without mercy and to the general discomfiture. The present is a moment of reaction on the part of those whose chief grievance was against those things termed reactionary. It is true that lack of principle is not confined to any one class and that example is catching; but sense recognises limits to any exploitation, and surrender of privilege has already been made without evoking any corresponding stimulation to effort.

During the war there was a common adversary; with some notable exceptions the period of hostilities did close our ranks and give at least the semblance of unity. It was a cynic who remarked that mutual aversion was a stronger tie than identity of interest, the most diverse will associate upon a common basis of hostility, rather than toward any co-operative end of mutual benefit.

There must be some unfathomable reason for prevalent industrial troubles which neither adjustment of conditions, shorter hours and increased pay serves to pacify. Indeed, these things seem to add fuel to the fire, those to whom are granted favours which they term rights use each concession as a lever for fresh demand. Employers generally have realised that workers are rational beings, who desire to live, and, living, to have a share in those things which enrich and adorn life. It is insufficiently realised that most of the good things of life may be commanded by a moderate income; the real things which matter most are not unattainable under the newer industrial conditions. During a long period of control most employers have been forced to conform to standard hours, increased wages and better conditions. In bare justice the results have surprised those most opposed to the changes. Yet the workers remain suspicious, they question the motive behind the action, wonder whether privilege would be bestowed without ulterior motive for favour so unusual. Reduction

of hours and increase in real wages cannot continue indefinitely unsupported by any answering increase in production; the claims current, backed by veiled threats are of such a character that compliance would be sheer weakness. Unless the idea is to reconstruct society upon an inverted basis present demands mean not the stabilisation of industry but its funeral.

It matters little what hours are worked provided that the outcome is economic, and that the individual produces a surplus over subsistence; giving both himself and the community to which he belongs the vital margin essential to rational existence. Unless a substantial overplus is created, civilisation is bankrupt, and a gradual descent into less tolerable life is certain. This margin has to provide relaxation, civic convenience, common utilities, a sinking fund against contingencies, the maintenance of the fabric of the State, and numerous other things commonplace enough-taken for granted rather than realised. It is beside the queston for the moment whether such margin is termed profits, taxes, rates, conveniences, transport, holidays, national protection or private luxury; such an overplus is vital to the lowly as well as to the more highly placed. Wealth is the command of resource, the production on demand of something beyond bare necessity and its relative total amount is exactly dependent upon individual production above individual need. Should labour as a whole determine that such a surplus shall not exist, then it will assuredly suffer with the rest. It is sincerely hoped that reason and judgment will temper the present situation, the future in any event is an uncharted sea where troubles enough will be found without internal dissension. Industry as a whole has been enfranchised, but while political minorities recognise that they must have patience and submit, the industrial electors refuse so reasonable a process. They have to realise that sudden demand cannot result in sudden concession without open discussion and collective bargain founded upon reason and merit. To secure a small privilege they will compel all the rest of mankind to suffer hardship and suffering for an inadequate cause. Moreover, nothing can be realised without public sympathy and concurrence, and assuredly they can have no hope of this. Should such trouble become periodic, it will be easy to find competent volunteers for essential services. There is a large reservoir of adaptable units who only require organising and, afforded adequate protection, essential services can and will be maintained. There are also other means open to the community to protect themselves, and, failing settlement, persistence or recurrence, these will undoubtedly be put into operation. Perverse beliefs require education, perverse action requires stronger handling, and even in the most democratic community the good of the majority must take precedence of the minor grievances of tiny minorities who have special machinery for the settlement of disputes.

WATERTIGHT DOORS IN MERCHANT SHIPS.

It is now possible to analyse experience during the great test of war on the question of watertight doors in ships. The controversy usually centres around the need or otherwise for doors in watertight bulkheads, and the difficulty has been expressed by saying that the question is one of the safety of the ship *versus* the convenience of the departments working the ship. It was abundantly demonstrated during the war that watertight doors when left open are a positive source of danger. The majority of vessels lost were sunk by the explosion of a mine or torpedo, and it was found that any bulkhead in the vicinity of the explosion was usually distorted to such an extent that it was impossible to close the door. Actually it was found that if the door was open at the time of the explosion there was generally, with few exceptions, no time to shut it even if it had been in working order. It has often been proved that watertight doors are open when an unforeseen contingency arises. It has also been shown that it is not possible to rely upon a crew, however well disciplined, to close watertight doors in an emergency. Examples of this occurred during the war, where in many cases a watertight door was far enough from the centre of the explosion not to be distorted, but only in isolated instances were such doors shut after the explosion occurred. For example, a large passenger vessel, 500 ft. long, was torpedoed without warning and capsized and sank in 5 minutes. The explosion laid open two compartments to the sea, but this would not have been in itself sufficient to sink the ship. Unfortunately the watertight door leading into a third compartment was open at the time, so that actually three compartments were opened to the sea. The large area of waterplane lost on this account was enough to destroy the stability of the ship, making her capsize. Other cases occurred where damage was received in the after part of the ship, destroying a shaft tunnel and thus admitting water to the engine-room through the watertight door at the forward end of the tunnel which was left open.

In the case of a collision a bulkhead between two compartments may be damaged, and it is of the utmost importance that the inrush of water should be confined to the smallest limits. The suggestion was made by the Court of Inquiry into the Empress of Ireland disaster that in circumstances of danger it would be desirable to close all watertight doors and port holes below the top of the watertight bulkheads and to keep them closed until the danger was passed. It will be remembered that the Empress of Ireland was sunk in collision with a collier; many lives were lost. The advice given by the Court of Inquiry is undoubtedly sound in theory, but in practice—especially in peace time—since the closing of ordinary watertight doors causes such inconvenience in the ship, it is not likely to be taken. If it is logical to leave out watertight doors in a ship because they are dangerous, it is equally as logical to leave out port holes.

During the war, a committee appointed by the Institution of Naval Architects recommended that all existing watertight doors low down in main bulkheads should be secured so that they cannot be opened, and that if watertight doors be necessary they should be fitted high up in the bulkhead. This was considered by the committee to be particularly important when bunker coal is carried forward of the boiler-room bulkhead, as a watertight door through which coal is being trimmed cannot be depended upon. In the ordinary way this would mean lifting the coal in the reserve bunker over the top of the boiler-room bulkheads, or through the watertight door openings cut high up in the bulkhead, thus necssitating extra work for the crew of the ship and an increase in their number.

In spite of all that has been said for and against watertight doors, the fact remains that watertight doors are still fitted, the evidence pointing to the convenience of working the ship outweighing the possible danger brought about by fitting the doors. That this is so seems fairly obvious, since the necessity for closing a door in an emergency may come once in, say, ten years, but the desirability of having it there occurs several times a day.

Access must be provided to coal bunkers, and although every effort should be made in designing a ship to arrange that the bunker bulkheads are non-watertight, this is by no means always possible, particularly under the Subdivision Rules. Then, again, there must be access between the boiler rooms and from them to the engine-room. Shafting requires periodical attention and watertight doors must be provided in the shaft tunnel for this purpose. It has been suggested that if watertight doors are dispensed with in the machinery spaces, access can be obtained to each watertight compartment from the top deck. This would mean increasing the number of engineer officers in a ship and adding to the wages bill. In addition, access trunks would have to be fitted in the 'tween decks or the engineers and greasers allowed in passenger accommodation. It is true that watertight doors are greatly cut down in warships, at least in the main watertight bulkheads, but in these vessels the number on the engine-room staff is not important, and in any case there are no passengers to consider. Economical considerations are relatively of little importance.

Even in warships, where efficiency is the first consideration, the number of watertight doors fitted is enormous. Some twenty years ago there was a sustained discussion with regard to this very question, the principal participants being the late Sir William White and the late Lord Charles Beresford. The former was in the position of having to put in watertight doors to meet the wishes of the senior naval officers controlling the design of warships. Lord Charles Beresford was anxious to reduce these, and while it is true he made some very drastic suggestions with regard to watertight doors low down in the main machinery bulkheads, he only proposed to do away with 19 out of a total of 208 in the battleship Magnificent. Since then some of his recommendations have been carried out, but even to-day in a first-class battleship there are nearly 200 watertight doors.

In passenger ships, watertight doors are generally necessary in one 'tween deck. It is curious in this connection, that the latest Subdivision Rules have actually added to the number of watertight doors required in a ship. It was usual before these rules came into force to stop the watertight bulkheads at a deck below the weather deck. Now, to get satisfactory subdivision, they must often be carried up to this latter deck. In the shelter-deck type of vessel, for instance, the main transverse bulkheads were only carried to the upper deck, and in consequence the passenger accommodation could be arranged in the shelter 'tween decks without introducing watertight doors in that space. Under the new Subdivision Rules it is frequently found necessary to carry the watertight bulkheads up to the shelter deck. In practice, as already indicated, it is necessary often to move from one compartment to another in the shelter 'tween decks, so that the bulkheads must be pierced and watertight doors fitted. These doors must be left open when the vessel is at sea. Watertight doors in a 'tween deck may be hinged or sliding, depending on the height of the deck above the water line. The danger of watertight doors in passenger 'tween decks being left open has often been demonstrated. When a damaged vessel has sunk to such a level as to bring the water into this 'tween deck over the damaged compartments, the water has promptly spread throughout the ship.

If there should be doubt still as to the need for watertight doors it should be removed by reference to the report of the Bulkheads Committee on the Subdivision of Merchant Ships. This report says, "The number of openings in watertight bulkheads shall be reduced to the minimum compatible with the design and proper working of the ship."

To summarise the position; watertight doors are objectionable principally because they are kept open and because in the ordinary way they require a great amount of effort and a good expenditure of time to open and close them. The necessity is for a means of opening and closing watertight doors easily. To do this the door must be operated by power. With such doors the convenience of the departments is met without endangering the safety of the ship. The principle of having watertight doors always closed can be applied to all those which are operated by power in the lower part of the ship, as, for instance, those in the machinery spaces. This disposes of the objection that after a ship has received damage it is not possible to close the door, since it is already closed. On the other hand, many prefer to leave the doors in the machinery spaces open.

We have remarked that it is quite hopeless to rely upon direct human action locally, so that the necessity for power operation controlled from some central position becomes apparent. The great advantage of a central control from the bridge is that this control is under the ruling brains of the ship, *i.e.*, either the captain or the first officer, men who have been trained to act quickly and with presence of mind in an emergency and who, moreover, will actually see danger approaching in 99 cases out of 100, and will be able to throw over their door control lever before the actual moment of impact, thus forestalling the danger of distorted door frames to which reference has already been made. With regard to doors in passenger 'tween decks which cannot be kept closed without a great deal of inconvenience, it is safe to say that the 'tween deck bulkheads would not

usually be distorted by an ordinary peace time accident unless the bulkhead was completely destroyed. In consequence it is possible to operate these doors, but that they should be closed quickly goes without saying, and what has been said for power-operated doors, centrally controlled, applies.

With regard to watertight doors in bunker bulkheads, the great objection to them is that they are likely to become partially blocked with coal. Here, again, the power-operated door has a distinct advantage in that the power can be made great enough to make the door cut through the coal. Nearly all the prominent steamship lines have fitted their passenger vessels with a centrally-controlled, power-operated watertight door system, and reports show that during the war it has been more difficult to sink these, than ships fitted with the ordinary watertight doors. With the power-operated doors there is often a certain amount of nervousness at first, amongst the men, with regard to their use, but in practice it is found that this is overcome when the men see that the local control is in their own hands and is quite sufficient to act against the central conrol, although the latter is made to close the door after the local action is taken off, this being usually done automatically. A power system of watertight doors does cost extra money, but this can be looked upon as an insurance premium.

The International Convention Rules for watertight doors, in vessels carrying more than 200 passengers, make it necessary to have, either doors which close by their own weight or by power pressure, and in any case operated from the bridge. Actually it is not often possible, in practice, to make all the watertight doors in the machinery spaces slide vertically so that they will close by their own weight. The result is that power-operated doors must be fitted, so that the Convention Rules do, in effect, require a power-operated, centrally-controlled system of watertight doors in passenger steamers.

In a passenger vessel, therefore, the choice remains between solid bulkheads and centrally-controlled, power-operated doors, and the advantages of doors are so obvious as compared with the inconvenient system of unpierced bulkheads that, in these days of high wages and short working hours, it follows that the moderate expense of installing an efficient power system would quickly be exceeded by the wages bill where solid bulkheads were fitted. It appears certain that all liners will in future have their bulkheads pierced for watertight doors, and that such doors will be centrally controlled and operated by power.

MORATORIUM FOR FRENCH PATENTS.

We have suggested on several occasions that patentees should be given a chance to obtain a prolongation of their rights on the presentation of proof of the disabilities which they have suffered during the war. The matter is one which we regard as of importance. It has been thought by some that the Government would introduce a Bill dealing with this, that is to say, with a moratorium for patents which expired during the war and also for patents still in force, the effective term of which would be reduced owing to the inability to work them during the past five years. The Government have always held out against bringing in such a Bill as they suggest that, as practically every one has been adversely affected by the war, and that there is no reason for preferential treatment to be given to inventors. The view held by our Government, we are glad to say, is not held by the French Government.

On the 10th inst. a law was promulgated in France which provides that the duration of French patents shall be extended for a period up to eight years in those cases in which the patents had not expired on August 1, 1914, or had been granted or applied for after that date, but before August 1, 1919. The law provides that the prolongation of patents is to be granted to those patentees who have not been able to exploit their inventions, and the duration of the prolongation is to be based on the period of time during which the normal exploitation of an invention has been suspended and of the results of the working of the patent if suspension has not been complete.

The Rules of Practice under which prolongations will be granted under this new law have not yet been issued, so that it is impossible to say at the moment how the law will be interpreted, though we understand that prolongations will be granted liberally. The rights of foreigners are not referred to, but we are given to understand that these rights will be dependent upon reciprocity.

The French Government have in this new law taken a decisive step which will be of inestimable benefit to patentees, and which we hope will be copied by the Governments of other countries.

In considering the position of patentees we are afraid that our Government has not looked at the matter from every point of view. We have explained in the past that the Government are inserting in the Patents and Designs Bill, 1919, now before the House of Lords, words which will permit the Court in a petition for prolongation to have regard to any loss or damage which may have been occasioned to the patentee by reason of the recent hostilities, and we have also explained that a petition for prolongation can only be presented near the completion of the patent term, which is not, in our opinion, a proper time to consider such questions, having in view the fact that the matter will in many cases be complicated by considerations bearing on the nature and merits of the invention in relation to the public.

It appears to us that the Government has entirely overlooked a most important point and one which has entirely escaped notice, but which will inflict considerable hardship on British patentees and manufacturers. This will now be especially the case, owing to the new French law. Let us assume that an inventor has applied for British and French patents and that these patents have been so applied for that they will expire practically simultaneously. Let us also assume that the French and British patents are now in the hands of different proprietors. The French patentee cannot export goods made in France to Great Britain while the British patent is in force, and the converse also holds. If the owner of the French patent be granted a prolongation he will be in the happy position that he can manufacture in France, supply his home market and also export his goods to this country and compete with the owner of the expired British patent; but the owner of the expired British patent will not be able to compete in the French market and will have to withstand the competition both of the French manufacturer and of other British firms in the same line of business. We have recently had brought to our notice several instances in which this condition of affairs will obtain, and it seems to us it is such an important point that it should be impressed upon the Government as strongly as possible so that our markets may be protected from competition in the same manner as the French.

NOTES.

International Standardisation.

Among the immediate interests of labour troubles, and outcries for increased production, it is useful to reflect at times that the solution of our manufacturing problems and the ultimate security of an improved standard of living all round by an increase in the quality, or quantity, of output per worker cannot altogether be secured by direct action. Such an apparently remote activity as that occupying the attention of the International Electrotechnical Commission, which has been meeting in London this week, has actually a direct relation to questions of increased production and the prevention of waste. This point of view was well put by the Right Hon. A. J. Balfour, who spoke at a dinner to the delegates of the Commission on the 21st inst. Mr. Balfour pointed out that standardisation was in effect a development of the movement for the division of labour on which the efficiency of all human industry ultimately depended. It was a great labour-saving arrangement. There was a good deal of disputation, sometimes worse than disputation, about the distribution of the products of modern industry. He was firmly convinced, however, that the distribution of what we annually produced was nothing compared with what there was to distribute. Increase the products and the industries of the world and they could leave the distribution alone. If men of science by their own special work increased economic manufacture they would do more to increase the well-being of mankind than those who filled the newspapers were always ready to admit. The dinner at which Mr. Balfour spoke was given by the British National Committee of the International Commission, in conjunction with the Councils of the Institution of Electrical Engineers and the British Electrical and Allied Manufacturers' Association. Sir Richard Glazebrook, who was in the chair, paid a well-deserved tribute to Sir John Wolfe Barry as the father of standardisation in his initiation of the Engineering Standards Committee, while Dr. C. O. Mailloux, representing the American delegates, paid a similar tribute to Colonel Crompton, speaking of him as the father of international standardisation, in view of his scheme for an International Commission first brought forward at St. Louis. From small beginnings the Commission had grown until at the present meeting twenty countries were represented.

Geared Turbines and Air Compressors.

In a paper recently published in the *Bulletin de la Société de l'Industrie Minéral*, M. A. Dessemond gives particulars of some interesting experiences with air compressors coupled by belting to a de Laval steam turbine. The latter was rated at 425 h.p. and the wheel turned at 7,500 r.p.m. This was reduced by the usual de Laval gearing to 750 r.p.m. at the belt pulley. The first compressor installed had three cylinders and was designed to compress 48½ cub. m. of air per minute and deliver it at a pressure of 7 atmospheres (absolute). Its designed speed of revolution was 150 turns per minute and the compression was effected in two stages. With this compressor a high efficiency was attained, but it proved less satisfactory from the mechanical standpoint as there were frequent compulsory stoppages due to accidents either to the compressor or to the turbine gears. The wheel and the gears had, in fact, to be replaced five times in six years, at the end of which the compressor, as the result of an accident, was replaced by another type of two-stage machine running at 280 r.p.m. This compressor proved satisfactory considered as an individual unit, but the turbine failures continued, the gears having to be replaced four times within the year. An examination of the teeth led to the conclusion that they had been subjected in service to a cold hammering process, and it was suspected that this was due to the fact that the compressors had a varying torque. A first investigation into the matter gave little support to this hypothesis, since in normal working the cyclical fluctuations in the torque were found to be less than the limit prescribed by the turbine builders. It appeared, however, that for one reason or another the discharge pressure often fell from 7 atmospheres to less than 5. Under these conditions the high-pressure cylinder of the compressor had to do much less than its normal work, and the cyclical variation in the torque was then much greater than at full load. It was accordingly decided to replace this type of compressor by a Reavell machine, in which the full compression was effected in one stage, and the cyclical variation of torque was accordingly not affected by fluctuations in the discharge pressure. With the adoption of this compressor turbine troubles ceased, and the plant has run for over two years without a single compulsory stop. Incidentally it was found that with this compressor the output could be regulated by adjusting the turbine speed. In fact, the turbine was found to run perfectly at any speed between 7,500 r.p.m. and 3,900 r.p.m.

The Electric Resistance of Pure Metals.

In discussions of the electric resistance of metals the complaint is often heard that there are few systematic observations extant of the changes of the electric resistance with temperature. Certain metals have been studied at relatively high temperatures; in recent years some metals have been investigated at decidedly low temperatures. But there are very few series of observations covering, for the same metal, both the low-temperature and the high-temperature ranges. An account of a recent investigation of this kind, conducted at the Reichsanstatt, was published by L. Holborn in

the *Annalen der Physik* of June 20 last, pages 145 to 169. The temperature coefficient of the electric resistance of a metal increases with its purity and attains its maximum at the highest purity. This, Holborn points out, is apparent from two facts. When old and new tables are consulted, it is found that the coefficients increased as the specimens available were in a purer condition; further, all alloys have a smaller temperature coefficient than the constituents. Holborn's first table clearly brings out the historical point. The first determinations of the electric resistance of metals at different temperatures were made by Dewar and Fleming in 1893; then followed Holborn and Day in 1899, Jaeger and Diesselhorst in 1900, Niccolai and various other experimenters, and finally in 1917 Bridgman, and in 1919 again Holborn. In most cases the resistances and their temperature coefficients grew smaller with renewed investigations, but the temperature ranges were generally not large, as we stated; the most complete series are the last two mentioned. Like most of the other workers, Holborn experimented with wires, hard drawn or annealed; the condition of the wire is not always clear in some of the early accounts. His temperatures were generally: —192·7 deg., —78 deg., 0 deg., + 100 deg., 200 deg., 300 deg., 400 deg., 800 deg. C. When a hard-drawn wire is annealed, its resistance R_0 (at 0 deg. C.) decreases and its temperature coefficient α increases; but these effects are sometimes reversed below 500 deg., especially for metals of low melting points. The rule, that the product $R_0 \alpha$ should be constant, is found to be roughly true only. Holborn determined the ratio of the resistance at any particular temperature R to the R_0. At —192·7 deg. he finds that iron had the lowest R/R_0 of any metal, *i.e.*, 0·0999; the value increased at higher temperatures to 4·776 at 407 deg. and to 6·04 at 500 deg. The iron was electrolytic or reduced from nitrate; the two series of values differed little and agreed on the whole with those of Dewar and Fleming, whose iron was exceptionally pure. The tungsten was taken from a lamp or from the crystallised wire of Pintsch which we have noticed. The very pure bismuth did not change its resistance after being heated to 100 deg., as had been asserted; there was such a change in copper after long heating because the copper became oxidised. When all the metals were arranged in a series according to increasing R/R_0, the iron metals (at the beginning) and the platinum metals (at the end) stood apart from the others. The α of the iron group was 1·5 greater than that of the other group, and the R/R_0 increased most with rise of temperature, but when iron and nickel lost their magnetism (above 700 and 400 deg. respectively), the α became smaller; good cobalt specimens could not be obtained. In the case of platinum, palladium and possibly tantalum the α increased only a little with rising temperature. Aluminium differed from all the other metals in so far as the purest metal did not show the highest α; this point is being further investigated. When the R/R_0 were plotted as ordinates against temperature, all the metals gave fairly straight lines, converging (so far as investigated) towards the absolute zero; but the lines were not really straight, and decided curvature was noticeable in zinc, cadmium, lead and particularly in bismuth. Of all the metals examined platinium alone seemed to give a resistance curve which could be expressed by a quadratic formula covering a considerable range; thus there is little hope of replacing platinum as a material for resistance thermometers.

The Wiring Rules of the Institution of Electrical Engineers.—A series of amendments to their Wiring Rules has been issued by the Institution of Electrical Engineers. These bring the rules into line with the latest figures published by the British Engineering Standards Association. The most important of the amendments takes the form of a new table of current capacity, insulation resistance, dimensions, &c., for rubber and paper insulated cables. The table replaces the old table of the seventh edition of the rules. Of the other amendments most are of a minor nature, but the rules relating to the method of supporting unarmoured lead-covered conductors have been considerably modified. Copies of the flyleaf containing the amendments may be obtained gratis on application to the Institution of Electrical Engineers, at their temporary office, 1, Albemarle-street, London, W.1.

LITERATURE.

The Iron and Steel Industry of the United Kingdom under War Conditions: A Record of the Iron and Steel Production Department of the Ministry of Munitions. By F. H. Hatch, Ph.D. With illustrations and diagrams. Privately printed for Sir John Hunter, K.B.E., by Harrison and Sons, London, 1919.

With the restraint becoming an official record, Dr. Hatch tells in this book a tale of national effort in which successful endeavour and abundant resource are so happily blended that we welcome the details and statistics that in other connections might prove wearisome. The history of the iron and steel industries in those eventful years of the war, when failure to supply the needs of the Army and Navy would have entailed the most serious consequences, possesses something of the interest of a powerful romance, and one that is read not the less willingly because it is known that the last chapter brings a happy ending. At the time when the demand for the raw material of munitions was most urgent, foreign supplies were most restricted, skilled labour was most depleted, fuel was most limited, and the industrial outlook most gloomy. Yet, in spite of these adverse circumstances, Dr. Hatch is able to report that the maximum output reached a figure that was never attained in the days of peace and prosperity, and, further, that at no time did any furnace have to go on slack blast for want of ore. With this record of the nation's capacity in the hour of severe trial and of the successful struggle against the most critical conditions, one cannot but believe that any loss of industrial prestige will be short-lived, and that recovery will be thorough and complete.

The description of the steps that averted the threatened crisis divides naturally into two portions. The former is marked by the growing acuteness of the situation in consequence of the stocks accumulated in past years disappearing under the stress of an unparalleled consumption; the latter by the successful development of the plans designed to increase the output, by the thorough organisation under Sir John Hunter of all the resources of the steel industry. Sir John Hunter had been Director of Factory Construction since 1915, and the erection of 17 large national factories throughout the kingdom bears witness to his energy and foresight. In August, 1916, he was asked to assume the post of Director of the Steel Section of the Raw Material Department, and a little later he was authorised to take whatever steps he considered necessary for securing an increased production of iron ore in the United Kingdom. The growing severity of the situation and the need of remedial measures of a drastic character were shown in various ways. The War Office had been compelled, but with evident reluctance, to sanction important modifications in the specifications for shell-steel. At the outbreak of the war the Department insisted that the steel used in shells should be made by the acid process. The revised specification first permitted both open-hearth and acid Bessemer steel, and subsequently basic steel was allowed. The percentage of phosphorus and sulphur in shell steel was raised from ·04 to ·05, and, as the stress grew keener, a maximum of ·06 and ·07 was permitted. After a trial of munitions in which higher percentages of phosphorus and sulphur were present, the authorities were satisfied that as much as 0·1 might be used with safety, notwithstanding the dangers arising from segregation, but for high-explosive shells used for land service the limit was fixed at ·08. The dread of shortage was further emphasised by the urgency of the appeal addressed to American manufacturers to furnish a regular supply. The proposal was rather coldly received, for in the States the works are built and organised for the definite production of particular classes of steel, and any departure from current practice introduces difficulties in each case, varying according to the nature of the normal output. All difficulties were eventually overcome, but it was not till near the end of 1916 that the first shipments were made, and from that time onwards one and a-half million tons of shell steel have been obtained from that source. But if sufficient labour had been forthcoming for the extension of the iron and steel works which had been projected, and to provide the fuel necessary to operate the new furnaces, the whole of the shell steel demand could have been furnished from home resources, effecting a very considerable pecuniary saving thereby.

The total deliveries of shell steel and the ratio between home and foreign product are shown in the following table, the return for 1918 being complete to about the date of the Armistice:—

Year.	High Explosives and Shrapnel in Great Britain.	Imports.	Total Deliveries in Great Britain for Land Service and Admiralty.	Deliveries to Allies.	Total Deliveries.
	tons.	tons.	tons.	tons.	tons.
1915 ..	145,900	nil	145,900	63,269	209,169
1916 ..	1,145,798	76,197	1,221,995	570,190	1,792,185
1917 ..	1,218,191	588,490	1,806,681	528,031	2,334,712
1918 ..	877,971	600,752	1,478,723	117,494	1,596,217

The diversion of so large a proportion of the steel produced to one particular purpose led to a shortage of steel available for general purposes, and numerous were the devices employed to remedy the deficiency or to equalise the distribution. These were no doubt irritating to the manufacturers and puzzling to the public at the time, but from Dr. Hatch's book it is clear that the insistence on precise limitations was a necessity, however unpleasant. One does not need to read between the lines to appreciate the anxiety felt at headquarters, the grave consideration given to the various expedients, the extreme reluctance to adopt restrictive measures, or the regret felt at the inevitable inconvenience caused to trade and commerce. While hearty acknowledgment is rendered to the organising power and skilful handling of the officials entrusted with this thankless and onerous task, we must also remember the self-denying patriotism and public-spirited action of the manufacturers, who co-operated cordially with the department. No trace is visible here of either friction or jealousy. Many placed their designs for new plant entirely at the disposal of their competitors. Those who were unaccustomed to special classes of work could obtain technical details of processes from those who had practical skill and experience in the work. One aim and motive animated all: "We will deliver the goods." These inspiring influences were naturally attended with happy results. As an instance, we may quote the Alloy Steel Trade. In July, 1917, the Air Board were obtaining 800 tons per month, an utterly inadequate quantity. A meeting of the principal makers of alloy steel was called, the situation explained to them, expert assistance given to those who needed it, with the gratifying result that before Christmas the supply had risen to 4,000 tons per month, and by the following May to 6,000 tons, a quantity in excess of that needed. High-speed and carbon tool steel was also placed under the control of an energetic committee, who undertook that there should be no shortage of tool steel for our munition work, and by their exertions raised the quantity manufactured from 6,000 or 7,000 tons annually to 18,000 tons, sufficient not only to supply our factories, but those of our Allies as well.

Interesting details are furnished of the construction of blast-furnaces and extensions to steel works, in order to increase the output of pig-iron and to preserve a due balance between this increase and the operations of the steel furnaces. With regard to pig-iron, the accumulated pre-war stocks were able to maintain an equilibrium between consumption and production till the middle of 1916, when the growing depletion of hematite pig occasioned anxiety. Naturally, the diminished supplies of foreign ore were displayed in the scarcity of hematite, and it may be said that the diminished supply became more acute as the war progressed. To lessen the danger of demand outrunning production, it was proposed by Mr. Walmsley, the Director of Iron and Steel Contracts, to bring into operation additional blast-furnaces. In June, 1916, he proposed to construct and renovate 51 furnaces, the whole to come into blast by the end of 1918 and to be capable of yielding 19,000 tons per week

of both hematite and basic. The extension of steel works was to go on *pari passu*. The underlying principle of the financial arrangement made between the interested firms and the Ministry was designed to leave those co-operating in the scheme in possession at the end of the war with improved modern plant at approximately pre-war cost. The extensions sanctioned, while keeping in view the direct necessities of the war, were to be convertible to general trade purposes on the return of peace. The improvements introduced in both plant and machinery mark a great development in the steel-making industry, and these new works will certainly be a vital factor in the economic and industrial recuperation of the country.

Many of these furnaces and extension works did not come into operation so rapidly as was intended—shortage of labour and shortage of material both caused delay—but by March, 1917, 33 extra furnaces were in blast, giving an increased supply of about 900,000 tons annually. Unfortunately, the additional steel works that came into operation at the end of 1916 could not be fed even at the increased rate of production, and large importations of both hematite and pig had to be made from America, notwithstanding that all centres in which smelting is a large industry made increased outputs, though in some cases it was necessary to adapt blast-furnaces making hematite pig to basic. The total production of pig-iron during the war period is shown in the following table:—

Production of Pig-Iron During the War Period.

Year.	Hematite.	Basic.	Forge and Foundry.	Alloys.	Total Pig-Iron.
	tons.	tons.	tons.	tons.	tons.
1914 ..	3,225,403	2,002,500	3,369,516	326,354	8,923,773
1915 ..	3,564,276	2,272,684	2,701,215	255,484	8,793,659
1916 ..	4,042,014	2,290,549	2,423,575	291,845	9,047,983
1917 ..	3,921,927	2,722,791	2,378,870	298,190	9,321,778
1918 ..	3,556,748	2,986,827	2,301,802	240,975	9,086,352

The growth in basic in the latter period testifies to the success of the policy of Sir John Hunter. In this connection it may be mentioned that the total output of steel for 1918 was approximately 9,500,000 tons, of which 51 per cent. was produced by the acid process and 49 per cent. by the basic. Moreover, for the first time in the history of British industry, the output of steel made by the basic open-hearth process exceeded that of the acid open-hearth.

The construction of new blast-furnaces and the conversion and utilisation of old are of little service if suitable ore is not forthcoming, with sufficiency of labour to carry out a fuller programme. The known need for increased ore supplies led to many reports being sent to the Ministry of unworked deposits in various districts, but after strict examination and test this hoped-for relief proved unavailing. The Jurassic ironstone of the Midlands disclosed, however, a more promising source for basic iron, provided the necessary labour and materials could be supplied. The ironstone was near the surface, the overburden could be removed by steam navvies, no large addition to labour forces was needed, and to facilitate transport German prisoners could be utilised to construct the necessary railway connections with trunk lines. The average iron content and composition was not too favourable, as shown in the following table, but fortunately an agreement had been made with the leading steel makers that, in view of the national emergency, they should accept for basic pig-iron a maximum silicon percentage of 1·5, a maximum sulphur percentage of 0·1, and a minimum manganese percentage of 1·25:—

Average Composition of Jurassic Ironstones as Mined or Quarried (in Percentages).

—	Fe.	Si O_2.	$Al_2 O_3$.	Ca O.	S.	P.	Mol.Asre.
Cleveland	28·1	11·8	10·2	4·7	0·26	0·47	6·8
Northampton and Rutland-shire	32·5	14·7	6·1	2·7	0·10	0·60	15·2
North Lincolnshire	22·7	8·1	5·1	18·2	0·16	0·31	10·7
Leicester and South Lincoln-shire	25·2	10·9	8·0	9·6	0·11	0·25	16·4
Oxfordshire	24·0	10·2	7·6	12·2	0·06	0·23	15·6

These figures indicate that the development of home resources, with the view of increasing the basic iron supply, was not without its difficulties. This was the work of Sir John Hunter and his collaborators, and they have their reward. By their energy and tactful administration they saw the weekly output of basic pig-iron rise from the normal amount of less than 50,000 tons to a maximum of 65,530 tons. Only those who are familiar with the operations can appreciate all that is implied in this increase. To substitute for the rich imported ores of foreign origin a lean phosphoric ironstone of such a composition as that quoted involves special changes in plant, in supplies, in transport and in labour. Adequate specialised labour was an ever-present difficulty, for the action of the War Office was apparently neither helpful nor sympathetic. More than once the carefully-elaborated plans of the Iron and Steel Department came near being wrecked, and the constant delivery of steel ingots was jeopardised by the arbitrary and peremptory orders of the War Office. As late as March, 1918, men were withdrawn from the metal, mining and quarrying in a reckless fashion, and, though the orders were necessarily cancelled almost immediately, great temporary disorganisation was caused, which the military authorities might have prevented by the exercise of greater discretion.

More blast-furnaces working with poorer ore made an increased demand on fuel inevitable, and the production and distribution of metallurgical coke taxed the resources of the Department to the full. The situation was aggravated by the unsettled state of the trade. At the outbreak of the war, owing to a glut of coke, it was selling at the price of the coal put into the ovens, to the great loss of the coke makers. As a consequence, beehive and inefficient ovens were reduced in numbers and the price rose, but subsequently, when large quantities of benzine and toluene were required for munitions, coke was again over-produced, and the rapid changes from surplus to shortage placed coke makers at a great disadvantage. In 1915 some blast furnaces were on slack blast, owing to an inadequate supply of fuel, and efforts to organise production on a rapidly-increasing scale were carried on throughout the whole of 1916. The new blast-furnaces asked at first for an extra 40,000 tons per week, and later, when 57 furnaces were in full operation, 53,000 tons. The situation was even more critical at the end of 1916, for the foreign hematite ore, owing to enemy submarine action, was at a low ebb; blast-furnaces devoted to the manufacture of hematite pig-iron were diverted to basic pig-iron, calling for a further supply of coking coal, which could not be delivered under conditions of efficient commercial practice. By improved processes of coke-making, principally by increasing the temperature and reducing the moisture in the washed coal, the average output of coke per oven was raised from 1,133 to 1,320 tons annually. This increase of 17 per cent. was achieved with reduced labour and costs, and, further, a point of great importance where time was essential to success, was accomplished without building additional batteries of coke ovens.

There was, however, during the war an increase of 175 by-product ovens, the Government contributing one-fourth of the cost. These ovens will be capable of supplying 16,500,000 tons, requiring an additional 8,000,000 tons of coal, making in all an annual consumption of 30,000,000 tons. This addition represents the labour of 33,000 coal miners. In face of the diminished output from all causes and the present price of coal, this hoped-for increase is hardly likely to be realised. Of greater interest is the strenuous effort to reduce the number of beehive ovens and to replace them by recovery ovens. It cannot be too vigorously urged that any coal carbonised in non-recovery plant leads to alarming waste of valuable materials, in addition to a prodigal loss of heat units. In pre-war days only 58 per cent. of metallurgical coke was made in by-product ovens. The quantity is now increased to 80 per cent. As a result of the change a very considerable saving, estimated at more than 4,500,000*l.*, has been effected. This increase suggests that the time has come when the Government might fix a time limit, after which no beehive coke oven installation should remain in operation.

Limestone had to be furnished in increased quantities to feed the new blast-furnaces. Several centres were capable of supplying the demand, but there was a shortage of labour. The difficulty was surmounted by utilising prisoner labour, though some friction was created in the labour world by the Cleveland Miners and Quarrymen's Association. The daily output of the prisoners was not very satisfactory, owing to the absence of sufficient encouragement to continuous exertion. Payment by piecework proved the best incentive, but since the total daily earnings might not exceed a fixed limit, the inducement was not very enticing, more especially as the canteen supplies were curtailed there was little opportunity for spending.

The history of the collection and distribution of refractory materials, whether fireclay for moulding purposes in the foundries and acid-steel melting furnaces; or refractory sands, for which a substitute had to be found, as foreign import, on which we relied, necessarily failed, is the same as for limestone, and other materials for which the demand became greater as the labour collecting power diminished. Fireclay bricks for blast-furnace linings afford a fair example of the energy and willingness everywhere exhibited. The capacity of the works for making bricks was about 120,000 tons per month, but, notwithstanding the repeated withdrawal of skilled labour for military service, the output gradually rose to 135,000 tons per month. With ganister and silica, those indispensable refractories in steel-melting furnaces, the tale is always the same. In July, 1916, when it was believed that the works were exhibiting their fullest capacity, some 8,000,000 bricks of the ordinary size were forthcoming. Yet by May, 1917, in spite of shortage of labour, the monthly outturn was 10,500,000 bricks. In every department of manufacture where necessity pressed, production increased to a point never reached in the history of that industry. It is a marvellous tale that Dr. Hatch unfolds, and one which we are afraid the country fails to grasp to its full extent. It is not given to many to conjure up a mental picture of a million tons of coal, or steel, and to appreciate all the effort and labour necessary to accumulate, to transport, and to make these available in commerce. In recalling the efforts of those who have played a worthy part in achieving victory, let us not forget those great captains of industry, who in spite of difficulties and disasters, and without the support of public applause, faced their tasks with unflagging zeal, encouraged less able colleagues by their advice and example, and carried to a successful issue a work of organisation that earns alike our admiration and our gratitude.

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The Mechanical Engineers Pocket Book of Tables, Formulæ, Rules and Data. By the late D. Kinnear Clarke, M.Inst.C.E. Eleventh Edition, revised and enlarged by H. H. P. Powles, Assoc.M.Inst.C.E. London: Crosby Lockwood and Son, Limited. [Price 7*s.* 6*d.* net.]

Text Book on Wireless Telegraphy. By Rupert Stanley, B.A., M.I.E.E. New edition in two volumes. Vol. I. *General Theory and Practice.* Vol. II. *Valves and Valve Apparatus.* London: Longmans, Green and Co. [Price 15*s.* net per volume.]

British Workmanship in Aeroplanes.—In a former issue (see page 384 *ante*) we referred to a "Bristol" Fighter which had been in service in Holland. Recent visitors to Hendon have had the satisfaction of viewing this machine, for it has been piloted to this aerodrome from Holland by Lieutenant Versteegh, with another Dutch officer as passenger. Decorated by its present owners with a red cock, the machine presents quite an unorthodox appearance. During its stay in this country the machine has had far from an idle life, and the centres to which the visitors from Holland have paid aerial calls include Bristol, where they inspected the works of the British and Colonial Aeroplane Company, Limited.

THE "USCO" BOILER DRAUGHT INDICATOR.

Fig. 1.

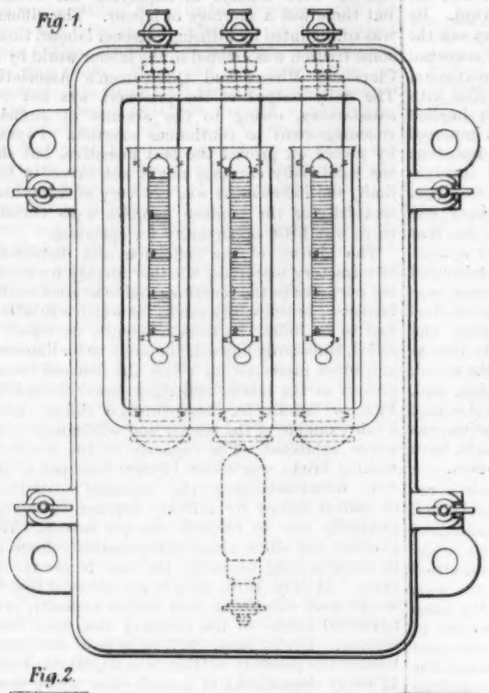
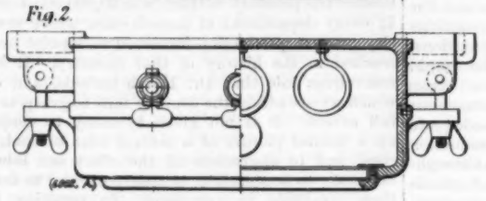


Fig. 2.



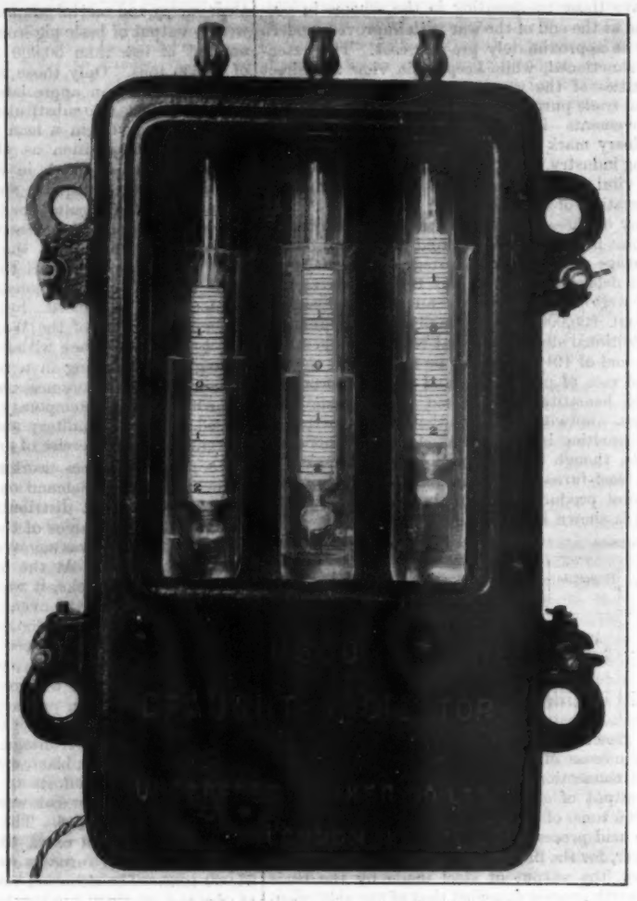


FIG. 3.

So much useful information as to the working of a boiler plant can be obtained from a complete knowledge of the draught conditions, that accurate readings of the air pressure at different parts of the system are of very great assistance in operating the plant at its maximum efficiency. For instance, if the difference of pressure above and below the grate to give the best results with any particular class of fuel be known for a given output, it will be evident, if a decrease in output occurs while the given draught conditions are maintained, that the fires require attention. Again, an increase in the pressure difference between the combustion chamber and the damper, while the other conditions remained constant, would indicate the fact that the boiler was becoming dirty. Such readings can, of course, be obtained by means of U tubes connected to suitable points in the path of the air and flue gases, but the U tube, as ordinarily constructed, suffers from the drawback that evaporation and condensation vary the quantity of water present in the tube, and so render the readings unreliable—at all events when obtained by an unskilled observer. In any case the readings of both arms must be obtained simultaneously, so that to determine the pressure drop between any two points four readings must be taken. More complicated instruments, usually provided with a dial, are, of course, simpler to read, but their construction necessarily involves the employment of more or less delicate mechanism, which may give rise to errors when used in a boiler-house.

The instrument illustrated by the drawing and photograph reproduced above has been designed and made by the Underfeed Stoker Company, Limited, of Coventry House, South Place, London, E.C. 2, in order to overcome the drawbacks briefly referred to above. It gives accurate direct readings, without the use of mechanism, and is of strong and simple construction, thus combining the advantages of the U tube with those of dial instruments, without the disadvantages of either type. As will be seen from our illustrations, the instrument comprises three indicating units enclosed in a cast-iron, dust-tight, case provided with a plate-glass window. Each unit consists of a central glass tube connected at its upper end to the point at which it is desired to measure the pressure. The lower end of this tube is open and dips into a large test tube, which is about half filled with water and surrounds the central tube for the greater part of its length, as shown in Figs. 1 and 3. If the pressure in the central tube is less than that of the atmosphere, the water will rise in this tube and fall in the outer tube, and the opposite effect will, of course, occur if the pressure in the central tube exceeds that of the atmosphere. In either case the difference of level between the surfaces of the water in the inner and outer tubes is proportional to the difference of pressure, and the method of measuring this difference of level is the most interesting feature of the instrument. Evidently some form of scale must be employed, but if this is either stationary or adjustable, its zero will be affected both by evaporation of the water and by condensation of vapour. To avoid this difficulty a floating scale, in the form of a hydrometer tube, is employed in the instrument we are describing. The scale, which is divided into inches and tenths with a central zero, is enclosed in a glass tube weighted so that it will float vertically in water, at normal temperature, with the zero of the scale at the water level. This float tube, which is placed inside the inner tube of the gauge, rises and falls with the water in that tube, so that the position of the surface of the water in the outer tube relatively to the floating scale is at all times a reasonably accurate measure of the pressure in the central tube. The float tube is kept central, and prevented from adhering to the inner tube, by a number of projections, or "pips," formed on the glass, and a similar arrangement is used to keep the axes of the inner and outer tubes coincident.

A glance at our illustration, Fig. 3, will show that the left-hand gauge reading is a pressure of 0·6 in. of water, the middle gauge a suction of 0·1 in., and the right-hand gauge a suction of 0·55 in. It should be explained, however, that, in an actual instrument, the water levels in the outer tubes are much more distinct than would appear from the illustration. As will be seen from Fig. 1, a small electric lamp is mounted inside the case at the bottom, and the light from this brightly illuminates the surfaces of the water in the outer tubes and so renders it easy to read the gauge from a considerable distance. This lamp, however, was not in use when the photograph from which Fig. 3 was reproduced, was taken. By close inspection it is possible to estimate the readings to within 0·02 in., which is a higher degree of accuracy than is necessary for most practical purposes. Another point to which we may, perhaps, call attention, is the effect of surface tension on the float. Careful inspection of Fig. 3 will show that, in each gauge, the level of the water in the inner tube is about 0·05 in. above the zero of the scale. This, however, does not affect the accuracy of the readings. If the floating scale is adjusted in a large open vessel so that its zero floats at the surface of the water, the latter will be slightly above the zero when the scale is placed inside the inner tube of the gauge due to surface tension. The surface of the water in the outer tube, however, will be exactly opposite the scale zero, if both tubes are open to the atmosphere, so that the reading of the instrument is not affected by this phenomenon. As the case of the instrument is quite dust-tight, the internal parts should not require cleaning very often, but the operation can be effected quite easily when necessary. The outer tube can be raised slightly out of the supporting ring, shown in Figs. 1 and 2, and then moved sideways and lowered together with the floating scale. The central tube can afterwards be pulled off the rubber "cork" by which the connection is made to its upper end.

The gauge illustrated is specially designed for use in connection with forced-draught boiler plants using "Underfeed" stokers. In such installations one of the indicators would be connected to the air-box of the stoker, and another to the combustion chamber. The difference in these two readings would give the resistance of the fire. The third indicator would be connected with the boiler flue near the damper, so that the difference between the reading of this indicator and that connected to the combustion chamber is a measure of the resistance to the flow of the gases through the boiler. As previously mentioned, it is possible to ascertain the condition of the fires, and of the boiler, at any time, by noting the readings of the

gauge and comparing them with the normal readings for the boiler working under the same conditions. The use of the gauge is, of course, not confined to forced-draught installations. It can be used equally well with natural draught, the scales then being graduated to read suction only. The instrument also appears to be well suited for measuring small pressures, or partial vacua, in industrial applications other than boiler plants.

INDUSTRIAL NOTES.

Employment, says *The Labour Gazette*, improved generally during September, and until the beginning of the railway strike was better than in any previous month of the present year, being good, or fairly good, in all the industries reported on, except the linen trade, some branches of the textile bleaching, dyeing, printing and finishing trades.

The railway strike, which began on September 27 and was settled on October 5, resulted in a large amount of unemployment in the coal-mining industry and in the great coal-using trades, *e.g.*, the pig-iron and iron and steel industries, which have not yet fully recovered from the effect of the stoppage; but many trades were not seriously affected. It is estimated that not less than 375,000 workpeople were unemployed for varying periods as a result of the railway strike. This figure excludes workpeople who were only placed on short time.

Changes in wages which came into operation in September resulted in increases being obtained by about 210,000 workpeople, while reductions in hours of labour affected about 25,000 workpeople. The general level of retail prices of food and other items at October 1 was about 120 per cent. above the pre-war level, as compared with 115 per cent. a month earlier.

The number of out-of-work donation policies lodged decreased from 478,084 at August 28 to 403,003 at September 26, distributed as follows: Civilians—men 62,435, boys 3,151, women 32,915, girls 2,230; demobilised—men 300,251, women 2,021. Of the total number of civilians 29,734 were in receipt of the reduced donation paid after the expiry of the first period of 13 weeks' unemployment. During the railway strike the number of policies lodged rose to a maximum of 676,171 on October 9. In addition to this number 85,000 workpeople received donation direct from their employers.

The number of men on the live registers of the Employment Exchanges at October 10 was 453,347, or an increase of 34,504 on September 12; and the number of women was 97,057, or a decrease of 3,156 on the total at September 12. The number of vacancies unfilled on October 10 was 34,178 for men and 43,600 for women, the corresponding figures for September 12 being 38,302 and 45,022.

Trade unions with a net membership of 1,418,265, excluding those serving with H.M. Forces, reported 1·6 per cent. of their members as unemployed at the end of September, as compared with 2·2 per cent. a month earlier and 0·5 per cent. a year earlier. The decrease in unemployment as compared with August is mainly due to the improved position in some branches of the textile trades, which were severely affected a month earlier by the coal strike in Yorkshire. These figures relating to unemployment among members of trade unions at the end of September may be taken as indicating the position before the railway strike began to affect employment.

The following notes refer to the state of employment in the various industries prior to the railway strike:—

Employment at coal mines in September was good; the number of workpeople employed at the collieries included in the returns was slightly greater than in the previous month, and 22 per cent. greater than a year earlier. At iron and shale mines and at quarries employment continued good, and at tin mines it was fair. In the pig-iron industry and at iron and steel works employment was good on the whole. In the engineering trades it was fairly good until towards the end of the month, when it was affected by the strike of ironfounders. In the shipbuilding trades there was considerable variation, and on the whole employment was not so good as in August. At tin-plate mills employment was good, though some mills remained idle owing to lack of water. In the other metal trades employment, taken as a whole, was fairly good, but not so good as in August.

In the cotton trade employment was fairly good on the whole, and showed little change in September as compared with the previous month. The woollen and worsted trades had largely recovered from the effect of the Yorkshire coal strike, and employment in these trades was good. Employment in the brick, cement and pottery trades continued good, and in the glass trades it was good, and much better than in August, when the Yorkshire glass bottle industry suffered severely from shortage of coal owing to the strike at the Yorkshire collieries. In the building, woodworking and furnishing, paper and printing, and food preparation trades employment continued good on the whole. With dock and riverside labourers it was fairly good, but with seamen only moderate. With fishermen it was good. The supply of unskilled agricultural labour was generally equal to the demand, but the shortage of skilled workers continued.

The changes in rates of wages reported to the Department as having come into operation in September resulted in an increase of about 48,000*l.* in the weekly wages of nearly 210,000 workpeople. The principal increases affected pottery workers in North Staffordshire, workpeople in the vehicle building and wheelwright trades, and tinplate workers in South Wales and Monmouthshire. Changes in hours of labour during September affected nearly 25,000 workpeople, whose recognised working time was reduced by an average of nearly seven hours per week.

According to *The Labour Gazette*, the effect of the recent railway strike was first apparent in the coal-mining industry, which is peculiarly susceptible to a stoppage of transport facilities. In the very early days of the dispute a considerable number of pits were laid idle, and though at other collieries a certain amount of coal was stocked, each day of the strike showed an increase in the number of collieries closed or working with reduced staff. The district most severely affected was South Wales, where over 200 pits were laid idle. The effect of the strike on coal output may be gathered from the following provisional figures relating to production in the weeks ending September 27 and October 4:—

	Tons.
Week ending September 27	4,481,434
Week ending October 4	2,871,610

The average percentage decrease is 36, being as high as 76 for South Wales and Monmouthshire alone.

Last Monday a conference was held at the Ministry of Labour, between Sir Robert Horne and Mr. Arthur Henderson, M.P. (Ironfounders), Mr. W. Thorne, M.P. (General Workers), Mr. J. T. Brownlie (Amalgamated Society of Engineers) and Mr. J. Hill (Boilermakers), on the question of the consolidation of war advances and bonuses into permanent rates of wages after November 20, when the Wages (Temporary Regulation) Act expires.

In his reply, Sir Robert Horne stated that the matter was one for decision by the Cabinet, after full weight had been given to the opinions of both the employers and the employees.

The Liberty and Property Defence League has prepared for immediate presentation to Parliament, a Bill under the title of the Trade Disputes Bill, with the double object of securing an interval for reflection before a trade dispute is allowed to develop into a strike or lock-out and of vesting in the members of a union (as distinct from the executive) the right to say whether the authority and funds of the union shall be employed for the purpose of a strike or lock-out. It is proposed to provide that a strike or lock-out, whether or not a union is concerned, shall not take place until 14 days after a statement relative to the dispute has been published by the Minister of Labour, and that a union shall not be concerned in a strike or lock-out until it has obtained the approval of the members. It is not intended to interfere with the right of members of the union to strike or not to strike whatever the result of the ballot, but if the ballot went against the strike they could not receive strike pay from the union.

The ballot of members of the ironfounders' and allied trades to which we referred in our last issue was declared at Manchester last Friday, and showed the following figures:—

Against acceptance of the terms	27,938
For acceptance	1,678
Majority against	26,260

Since the total membership is approximately 50,000, it will be seen that slightly over half the members recorded their votes.

Dealing with the situation, the *Sheffield Daily Telegraph* makes the following statement:—

What will be the next move? Many people engaged in Sheffield trades are asking this question in regard to the moulders' strike. The decision of the men not to accept the terms suggested by the conference caused general disappointment in Sheffield, and the future presents a most unpromising outlook. The figures of the ballot are evidence of the attitude taken up by the men. They are very firm at present; they have thrown overboard all constitutional means of settlement, and are pressing their full demands upon the employers.

"Nothing we could do or say would diminish their determination," said a local official of the Ironfounders' Society. "We are all very sorry that the negotiations failed; we were hopeful that both sides would give way a little, and that a basis of agreement might be reached, but there was nothing but complete failure. The number of men out of work will soon greatly increase, and the stoppage of the moulders and core-makers means that many of the skilled men will be thrown out. The Prime Minister saw something of the silent shops at Hadfields, and he could have seen many more if he had gone to other works. Perhaps he will make an effort to bring the parties together again; I hope he will, for unemployment will become more pronounced each week as the strike drags along."

The position taken up by the employers is that in view of the wages the moulders are receiving their new demands are unreasonable. "At the conference," remarked an employer, "their view appeared to be that we must give way, because stoppage of the moulders' shops means the stoppage of machinery and the closing down of departments. But we cannot give them all they want, even though they put a pistol at our heads. It is only natural that we want to settle, but we cannot adopt a policy of acceding to everything that is demanded, no matter how unjust those demands may be. The number of men thrown out of work by this strike is increasing; machines which should be turning out important and much-needed material are standing idle, and I hope—and in this hope I am joined by many other employers—that some one will make a still further effort to bring about another conference, in order that a new attempt may be made to settle this unfortunate dispute."

Foundry work was referred to by Dr. W. H. Hatfield, of the Brown-Firth Research Laboratory, member of the Iron and Steel Institute, and of the Institute of Metals, in the course of the presidential address which he delivered last Friday to the members of the Sheffield and District Branch of the Institution of British Foundrymen. Dr. Hatfield stated that he had visited foundries in America and on the Continent, and he was able to assure his audience that, as men engaged in the foundry trade they should, in the interest of the country, wake up quickly. It might astonish them to know that before the war, although the United States of America had a huge tariff, the comparative selling prices of some castings in the States behind that tariff were lower than the selling prices of castings in this country. It simply meant that the cost of production in the United States was lower than the cost of production in this country. In the first place standardisation was carried out in the United States to a much greater and more useful extent than in this country, and consequently a foundry, generally speaking, received orders for far greater numbers of castings for an individual pattern. Then there was the fact that manufacture generally was more centralised; the firms were larger, and, he believed, fewer. Moulding machines, too, were very largely used in America.

It should always be remembered that the moulder was a moulder. He should not spend his time labouring; he should be supplied with ample tools and materials and not have to wait hours for cores. The important question was the question of labour. If some satisfactory arrangement of piece-work could be fixed up, in which both the men and the firms concerned were satisfied, built on a basis of the present production, and if the British moulders worked as hard as they could for the period they were at work, he felt sure that that one change alone would do much to put the British foundry industry in a commanding position.

A meeting of the debenture holders in Wolseley Motors, Limited, took place last Monday, the 20th inst., when Sir Vincent Caillard, the chairman of the company, stated that the following were some of the contracts upon which the company were chiefly engaged during the war, and the approximate quantities supplied: Motor cars and lorries, including the equivalent in spare parts, 3,600; aeronautical engines, including the equivalent in spare parts, 4,900; aeroplanes, 760; aeroplane spare wings and tail planes, 600 sets; air screws of various types, 6,000; battleships, cruisers, flotilla leaders and destroyers equipped with director firing gear, 243; naval gun mountings and sights, 1,200; transmission mechanism for rigid airships, 10; 18-pdr. shell, 2,850,000; Stokes' bombs, 300,000. In connection with these contracts, the directors received a letter from the Admiralty expressing their appreciation of the exceptional services rendered by the company in respect of the work carried out for them, and the Air Board requested the directors to convey to the staff and workers their congratulations on the highly satisfactory performance of their productions.

"Now that the time has come," added Sir Vincent, "for the company to revert to its normal business, the directors have decided on the equipment of the works with a view to the manufacture of cars on a definite programme. In order to carry this into effect it will be necessary to take the following steps: (1) To

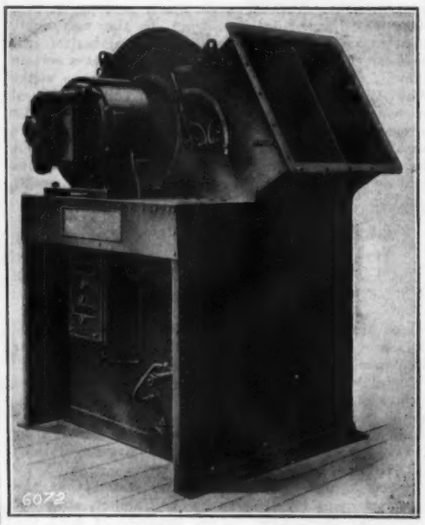
balance the machinery in the machine shops so as to bring every section up to the required standard for the programme on which the directors have decided. The stockholders will understand that while in some sections there may be machinery in excess of the requirements for the programme, and in such cases, such surpluses will be disposed of, in other cases the sections may not have a sufficient amount of machinery to keep pace with the weekly output, and in these cases additional plant has to be purchased, so as to bring the sections up to the required standard. (2) To provide additional factory space for assembling and erecting purposes. A large portion of the space which was used for this purpose in the past has been absorbed during the war for the installation of additional machinery. (3) To extend the company's body manufacturing, painting, trimming and finishing shops, which have not undergone any extension during the war. The broad position is, therefore, that the erecting, assembling and body departments of the company have now to be extended on lines parallel with the extensions which have taken place in the machine shops, so as to keep pace with the increased output of chassis. These developments would normally have been carried out at the same time as the machinery extensions, but under the circumstance this was impracticable. When these arrangements have been completed, the company should have a well-balanced manufacturing unit, which will be capable of producing cars to the limit of the capacity which has been decided upon by the Board. . . ."

Investigation of Markets in Chile, Peru and Bolivia.—The Department of Overseas Trade (Development and Intelligence) and the British Engineers' Association will shortly despatch to Chile, Peru and Bolivia a joint investigator to ascertain the conditions and prospects for the sale of British engineering products in that market. The cost of the investigation is being defrayed by the association and His Majesty's Government. The subjects to be covered by the investigator include imports, shipping methods, customs tariffs, legislative regulations and restrictions, statistics and competition. The investigation will be pursued in the following directions: (1) Civil engineering; (2) power plant and accessories; (3) mining plant (not tools); (4) plantation machinery—(*a*) sugar, (*b*) rubber, (*c*) coffee; (5) machine tools; (6) vehicles (railway, road, water, air); (7) electrical machinery and plant (not electrical accessories); (8) agricultural and dairy machinery (not implements). Firms who are not members of the British Engineers' Association may participate in the inquiry on payment, before the receipt of the first report, of a fee of 20 guineas, provided they are British manufacturing engineers or shipbuilders, or British manufacturers of articles necessary to engineering plant, or producers of raw materials, or British companies, firms or individuals who, while not possessing works of their own, hold patents or other proprietary rights in engineering plant or accessories thereto and contract for the manufacture of their specialities with members of the British Engineers' Association. Any communication relative to this investigation should be addressed to the Comptroller-General, Department of Overseas Trade (Development and Intelligence), 4, Queen Anne's Gate Buildings, Westminster, S.W. 1, or the Secretary, British Engineers' Association.

Scientific Research Association.—During the recent British Association week at Bournemouth an afternoon meeting was held in the Municipal College—which was for the week the home of the British Association—by the promoters of the Scientific Research Association, Professor A. Gray, of Glasgow, being in the chair. Mr. A. G. Tansley, F.R.S., of Cambridge, the acting secretary of the Scientific Research Association, explained that the new association had been formed at Cambridge in February, 1918, for the purposes of offering advice to those wishing to devote themselves to scientific research, to advise bodies administering funds for research, to organise a scheme of national endowment of research, and to impress upon the public the need of research. A subject committee was to be formed in each branch of science to report to the Council of the Scientific Research Association on the position of research in that branch; the General Purposes Committee was to communicate with the authorities; candidates for membership were to be engaged in research for publication, associates to be interested in science, and both classes of members were to pay an annual subscription of 10*s*. The papers circulated pointed out that the new Association did not mean to be a Cambridge organisation; it did not wish to interfere with cognate bodies, and it did not oppose in particular, though it could not co-operate with, the National Union of Scientific Workers, the aims of which, though similar, were largely economic, but the organisation of which was based on local trade union branches. Circulars sent out last spring to 2,000 scientists had only elicited 250 replies, and the question was whether, in view of the apathy and hostility shown, the movement should go on. The first list of nearly 200 supporters, we may say, is undoubtedly strong. Professor Gray, who had advocated similar proposals in his presidential address to Section F (see page 397 *ante*), and others, spoke in favour of the suggestion. No resolution was passed, however, and that is hardly to be regretted considering the number of cognate organisations already in existence. We should add that the British Association had nothing to do with the meeting.

SHIP HEATING AND VENTILATING PLANT.

A new form of heating unit for supplying warm and, if necessary, humidified air to the state rooms, saloons, &c., of ships, is illustrated in the figure annexed. It is constructed by Messrs. James Keith and Blackman Company, Limited, of 27, Farringdon Avenue, E.C. 4. The output from the unit is conveyed to the various accommodation spaces on board ship by means of the customary arrangement of distributing ducts. The unit consists of an electrically-driven centrifugal fan mounted above a steam-fed air heater. The heater contains rows of solid drawn weldless steel tubes of hairpin shape, the ends of the tubes being expanded into a base casting which forms the steam and drain header. These tubes are arranged on an inclined principle, patented by the makers, the idea of which is to restrict the water of condensation to a limited stream within each pipe and so to improve the efficiency of heat transmission by eliminating much of the wet area of the inner surface of the tubes.



In determining the general form of the heater and the position of the fan, the necessity for avoiding undue pressure loss due to eddying, or quick irregular changes in cross-section of the air passages, has been kept in view throughout. It is claimed that for any specified pressure required in the delivery duct a comparatively low increase of pressure is required at the fan on account of the low internal losses. There is a by-pass valve fitted in the heater casing, so that any desired proportion of the air supply can be delivered direct to the air ducts without passing over the heater tubes, while for controlling the humidity of the air a perforated ring pipe is employed fitted with a hand-controlled steam valve. The unit is of the reversing type, so that if desired it can be employed for exhausting air from the spaces with which it is connected. Such an arrangement is required in cases in which passenger spaces are temporarily employed for storing cargo. This state of affairs sometimes arises in emigration vessels. This change-over can be made at any time simply by swinging over the lever which can be seen on the upper part of the casing in the figure. The lever controls an air valve, or damper.

SOCIETY OF GLASS TECHNOLOGY.

The first meeting of the new session of the Society of Glass Technology was held in the Fuel Department of the University of Leeds on Wednesday, October 15. Mr. S. N. Jenkinson presided. The first paper read on "*Some Recent Improvements in the Designs of Glass Works Furnaces and Gas Producers*," was by Mr. J. S. Atkinson. The first portion of the paper dealt with the design of gas producers. No matter how perfect a furnace is, in the author's opinion, satisfactory results cannot be obtained if the supply of gas is faulty, by reason of its irregular quality or quantity.

The fuels available in this country for use in producers are coke and coal. In small installations there is much to be said in favour of coke gas. In a properly-designed coke gas producer, a uniform supply of gas, both as regards quantity and quality, can be obtained, whilst the striking feature of this type of producer is that it can be run with unskilled labour. The author then described a coke gas producer in satisfactory use in a glass works. One important feature in the design is that the gas outlet is not placed over the fuel bed, but some distance down the side of the producer. Two very pronounced advantages arise from this arrangement:—

1. As the path of air and steam through the incandescent zone always remains constant, a gas of absolute uniform analysis is produced. In usual producer practice where the gas outlet is situated over the fuel bed, the thickness of the fuel bed will often govern the quality of the gas produced.

2. The space above the gas outlet and below the charging hopper is utilised for a reserve supply of coke, and about 12 hours' to 24 hours' supply can be stored here. The coke falls, due to its own weight, into the incandescent zone, and no poking is necessary. With this type of producer, great saving in labour is gained. The rate of gasification in the coke producer is under complete control, the producer can be placed close up to the furnace, or at any convenient distance away. In the author's opinion, the importance of keeping the producer close up to the furnace is often over-estimated.

Where coke is not available, a Siemens' dry bottom producer, using coal as fuel, can sometimes be employed with advantage. The great objection to this producer is the fact that an irregular supply of gas, both as regards quality and quantity is produced, due to the fact that each fresh charge of coal causes for brief periods an increased volume of gas to be given off. Better types of producers are the Dawson, Duff and Wilson, all of which are provided with a water seal, which allows a constant gas-making during the clearing out of ash. All three types, however, suffer from a disadvantage, due to the fluctuation in quality and quantity of gas produced in intermittent charging. Revolving grate producers have during recent years come to the front, and with certain grades of fuel possess great advantages. In the author's opinion they should be used with fuels containing a very high percentage of ash. Their prime cost is high, and their upkeep is expensive.

In order to approach as nearly as possible to the theoretically perfect producer, three primary conditions are essential:—

1 Constant feed of the fuel to the producer.

2. The even distribution of the fuel over the whole of the producer bed.

3. The constant agitation of the upper portion of the fuel bed.

These conditions are met, to a more or less degree of perfection, in the Talbot, Wood, Hughes, and Morgan producers. The Chapman agitator, with automatic feed, fulfils all these conditions, and has the additional advantage that it can be fitted to nearly all types of existing producers.

The author then described at length the design and manner of working of the Chapman agitator.

In the second portion of his paper, Mr. Atkinson dealt with the recuperative pot furnace of the Stein type. In this furnace the recuperative chambers are placed on either side of the furnace proper; thus the furnace acts as a unit, and the recuperator as another unit. No molten glass from broken pots can flow into the recuperators, nor have they any weight of the furnace to bear. In the Stein furnace the air passages in the recuperator are vertical. This, in conjunction with the regulation of the chimney chamber, allows of a positive flame pressure above the atmospheric pressure being maintained in the furnace, around the pots.

A 12-pot furnace in actual use has a fuel consumption of from 37 per cent. to 46 per cent. of the weight of the glass produced. The furnace has been running for over 34 months, and at present there are no indications that its efficiency is impaired. In conclusion, the author described a tank furnace with a novel arrangement of dampers, which allow individual control of the burners.

The next paper, by Mr. R. L. Frink, was "*The Manufacture of Table Ware in Tank Furnaces.*" Mr. Frink made a special journey from Paris to deliver his paper, a fact that was highly appreciated by the society. In the paper he described how it was possible to produce high-class crystal glasses, both flints and crowns, in tank furnaces. In the making of high-grade glass in tank furnaces, using producer gas, a factor which is of great importance, does not reside in the furnace, but in the gas generator. Unless gas can be delivered to the furnace uniform in volume and heat value, it is impossible to affect a temperature and fire regulation, upon which the success of the operation depends. An ample and uniform quantity of gas must be available, either an automatic gas regulator must be applied, together with a means of accurately determining chimney draught control, or conscientious, careful observation must be given to the adjustment of chimney damper air and gas valves. Care must be taken to have complete removal of gases of combustion as rapidly as they are produced within the furnace. Control of air must be such as to affect complete combustion. The furnace construction should be provided whereby gases will not come into contact with melting batch. There must be proper introduction and distribution of batch within the furnace, so that batch may be rapidly and uniformly melted. No furnace should deliver less than 9 lb. of glass per square foot of melting area per hour. With this rate of movement through the furnace, glass free from striæ and lamination can be obtained. The author claimed that with a proper designed furnace, properly operated, it was possible to produce a lead glass of far superior quality and homogeneity than could be possibly produced in pots.

A full and animated discussion followed both papers.

Motor Spirit.—The Board of Trade announce that the Profiteering Act, 1919, Maximum Prices Order No. 2, which fixed maximum prices for the sale of motor spirit, has been revoked.

Trade Marks in Roumania.—Information has been received by the Board of Trade from His Majesty's Chargé d'Affaires at Bucharest to the effect that the registration of trade marks has been resumed by the Roumanian Government.

ENGINE POWER AND HEIGHT.*

By H. T. TIZARD.

(*Concluded from page 528.*)

8. The "density theory" assumes as a first approximation that the density of the charge entering the cylinder is proportional to the density of the external atmosphere. The opposite point of view to take is that the temperature of the charge is independent of the external temperature, and that its density is therefore proportional to the external pressure only. Neither theory can be held to represent accurately the actual conditions, but the truth must lie somewhere between the two. To decide which theory most closely corresponds to the facts, a knowledge of the relation between indicated and brake horse-power is necessary. This relation is fairly certain; the mechanical losses of a modern aero engine vary from about 10 to 15 per cent. of the indicated horse-power on the ground, and of these a large proportion, caused by piston friction, magneto and water-pump drives, &c., must be practically independent of the density. The throttling losses, which account for about one-quarter to one-third of the total, are assumed generally to be proportional to the density, and a small error in this assumption is not of much consequence.

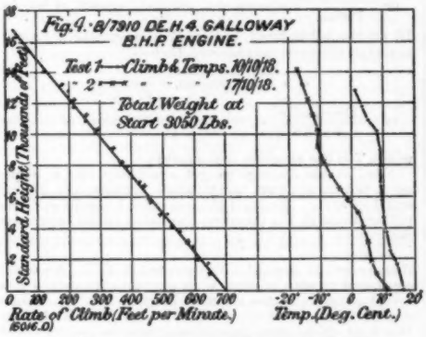


Fig.4. B/7910 DE.H.4. GALLOWAY B.H.P. ENGINE.
Test 1—Climb & Temps. 10/10/18.
2 - - - - 17/10/18.
Total Weight at Start 3050 Lbs.
Standard Height (Thousands of Feet)
Rate of Climb (Feet per Minute.)
Temp. (Deg. Cent.)

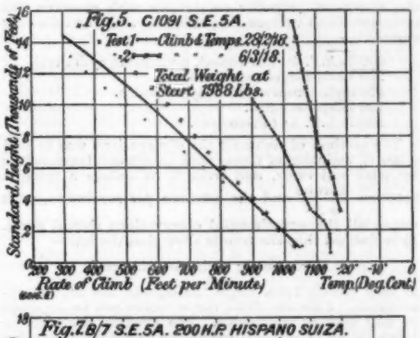


Fig.5. C1091 S.E.5A.
Test 1—Climb & Temps. 28/2/18.
2 - - - - 6/3/18.
Total Weight at Start 1388 Lbs.
Standard Height (Thousands of Feet)
Rate of Climb (Feet per Minute)
Temp. (Deg. Cent.)

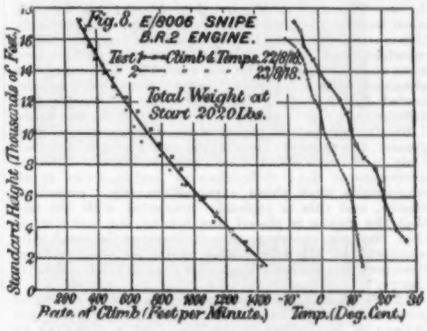


Fig.8. E/8006 SNIPE B.R.2 ENGINE.
Test 1—Climb & Temps. 22/8/18.
2 - - - - 22/8/18.
Total Weight at Start 2020 Lbs.
Standard Height (Thousands of Feet)
Rate of Climb (Feet per Minute.)
Temp. (Deg. Cent.)

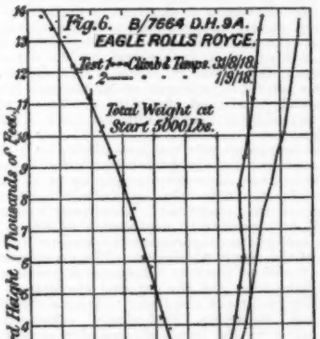


Fig.6. B/7664 D.H.9A. EAGLE ROLLS ROYCE.
Test 1—Climb & Temps. 2/8/18.
2 - - - - 1/8/18.
Total Weight at Start 5000 Lbs.
Standard Height (Thousands of Feet)
Rate of Climb (Ft. per Min.)
Temp. (Deg. Cent.)

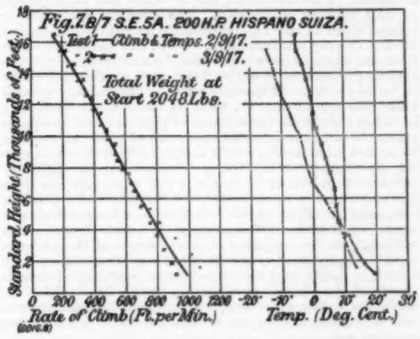


Fig.7. B/7 S.E.5A. 200 H.P. HISPANO SUIZA.
Test 1—Climb & Temps. 2/3/17.
2 - - - - 3/3/17.
Total Weight at Start 2048 Lbs.
Standard Height (Thousands of Feet)
Rate of Climb (Ft. per Min.)
Temp. (Deg. Cent.)

If we assume that the indicated horse-power is proportional to the density, and that the mechanical losses are 12 per cent. of the indicated power on the ground, of which one-third are throttling losses, we get the following relation between brake horse-power and density at constant engine revolutions—

$$B_\sigma = \frac{0{\cdot}96 \times \sigma - 0{\cdot}08}{0{\cdot}88} B_0$$

where B_0 is the brake horse-power at ground level.

Putting $B_0 = 1$, the values for B_0 at different heights are shown in the fourth column of Table VI:—

TABLE VI.

Standard Height.	Relative Density.	Relative Pressure.	Relative B.H.P. on Density Theory.	On Pressure Theory.
0	1·026	1·00	1·00	1·00
5,000	0·874	0·829	0·84	0·80
10,000	0·740	0·684	0·70	0·64
15,000	0·630	0·560	0·58	0·52
20,000	0·533	0·456	0·48	0·40

If, on the other hand, we assume that the density of the charge varies inappreciably with the atmospheric temperature and that the indicated horse-power is proportional only to the pressure, we get the relation—

$$B_p = \frac{p - 0{\cdot}08 - 0{\cdot}04 \times \sigma}{0{\cdot}88} B_0$$

* Paper read before Section G of the British Association at Bournemouth, September 11, 1919.

the results for different heights on a "standard day" being shown in the fifth column of the table.

Now, analysis of performance tests shows quite definitely that the brake horse-power does not fall off to anything like the extent indicated in column 5. In a recent paper (Advisory Committee Report, No. T.1161), Mr. Bairstow outlines a method for obtaining the variation of horse-power with height directly from the results of performance tests. He takes the case of a Rolls-Royce Martinsyde machine, and shows that the variation almost exactly corresponds to that given in column 4 of Table VI. The evidence in this case is quite definite enough to show that the theory that indicated horse-power is proportional to the pressure and independent of temperature within the limits obtaining in normal flight is not even approximately true. This conclusion is confirmed by measurements of the depression in the choke tube during flight, as will be shown later. The alternative view put forward, that it is the brake horse-power that is proportional to the pressure and independent of temperature, ignores the important factor of mechanical losses altogether. If true, it would mean that the efficiency of the engine increased as the pressure fell, which is hardly conceivable. It is difficult, therefore, to find any theoretical justification for this view, but for the practical purpose of estimating the power at different heights one must accept it for what it is worth, and see how evidence from flight tests bears it out. It leads to a law of variation with height on a "standard" day, practically the same as that obtained by assuming the indicated horse-power to vary as the density. This will be seen by comparing columns 3 and 4 of Table VI. An important consequence of this is that it is impossible to be able from results of performance tests, or observations of propeller revolutions at different heights on any one day, to settle definitely which assumption gives results agreeing most closely with experiment. Evidence of this kind from flight tests is only of value when it is obtained by comparing results obtained on different days, on which the atmospheric temperatures at the same heights are considerably different.

9. The evidence obtained from measurements of performance will first be considered. As already stated, such performances have hitherto been "reduced" by comparing rates of climb, and full speed, at the same atmospheric densities. Suppose, for example, the rate of climb of an aeroplane at any standard height h is measured on two days on which the absolute temperatures at this height were T_1 and T_2. The density theory states that since the power depends solely on the density, the power at any standard height at constant revolutions per minute will be unaffected by change in temperature. The rate of climb at the same air speed ($\sigma^{\frac{1}{3}} V$) and the engine revolutions per minute will be the same on the two days. On the other hand, if the brake horse-power depends only on the pressure, then, since the pressure is greatest on the warmest day (since the density is proportional to $\frac{P}{T}$), the available horse-power and the rate of climb will then be greater. If this is true, the standard method of reduction tends to give too low results on an exceptionally cold day and to high results on an exceptionally warm day. The effect may be calculated as follows:—

If the brake horse-power at any standard height and revolutions per minute is proportional to the atmospheric pressure, it is also proportional to the absolute temperature. Hence, if the temperature varies from T_1 to T_2, the revolutions per minute at the climbing speed ($\sigma^{\frac{1}{3}} V$) vary from n_1 to n_2 and the brake horse-power available from $n_1 T_1$ to $n_2 T_2$, since for small differences of engine revolutions at the climbing speed the brake horse-power is nearly proportional to n.

Now, the brake horse-power is also proportional to—

$$\sigma \times n^3 \times f\left(\frac{V}{n}\right)$$

or, since σ is constant, to $n^3 f\left(\frac{V}{n}\right)$, where V is the forward speed and n the propeller revolutions. It can be shown that at climbing speeds an increase in n of 1 per cent., when V is constant, causes an increase of about 0·3 per cent. in $f\left(\frac{V}{n}\right)$. Hence an increase in n of 1 per cent. corresponds to an increase in brake horse-power of 3·3 per cent., since brake horse-power is proportional to $n^3 f\left(\frac{V}{n}\right)$. But since brake horse-power is also proportional to $n \times T$, we find that an increase in n of 1 per cent. is caused by an increase in T of 2·3 per cent., or about 6 deg. C. at the standard height of 10,000 ft.

10. To illustrate this we will consider two concrete examples. The first, the results of two climbing trials of a 230 B.H.P. D.H.4 at Martlesham Heath; the second that of two climbing trials of a 200 horse-power Hispano Suiza S.E.5 at the R.A.E., this having been put forward in support of the "pressure theory":—

(*a*) *B.H.P. D.H.4. Weight* 3,050 *lb.*

	October 10, 1918.				October 17, 1918.			
Standard Height.	Airspeed.	R.P.M.	Rate of Climb.	Temp.	Airspeed.	R.P.M.	Rate of Climb.	Temp.
ft.				deg. C.				deg. C.
10,000	68	1,280	305	−10·5	69	1,290	300	8

On the density theory the rate of climb and revolutions per minute should be unchanged. On the pressure theory, since the increase in absolute temperature of the hot over the cold day is 7 per cent., the increase in brake horse-power should be $\frac{7 \times 3{\cdot}3}{2{\cdot}3} = 10$ per cent. Taking the propeller efficiency as 70 per cent., this should give an increase in brake horse-power available for climbing of about 7 per cent. Now, the brake horse-power of a B.H.P. engine at 1,280 revolutions per minute is about 230, and at 10,000 ft. on the cold day would be approximately 157. Seventy per cent. of this is 11 horse-power, and since the weight of the machine was about 3,050 lb., this should have increased the rate of climb by 120 ft. a minute, or from 310 ft. a minute to over 400 ft. a minute. The actual increase was negligible.

(*b*) 200 *Hispano Suiza, S.E.5a. Weight* 1,988 *lb.*

	February 28, 1918.				March 6, 1918.			
Height.	Airspeed.	R.P.M.	Rate of Climb.	Temp.	Airspeed.	R.P.M.	Rate of Climb.	Temp.
ft.				deg. C.				deg. C.
10,000	62	1,645	0	−18·0	62	1,660	630	−8

The result is obviously at variance with the density theory. On the pressure theory we have an increase in temperature from cold to warm day of 6·3 per cent. The horse-power should increase $\frac{6{\cdot}3 \times 3{\cdot}3}{2{\cdot}3} = 9$ per cent. Taking the horse-power at the revolutions per minute as about 180 on the ground, the horse-power at 10,000 ft. will be approximately 122, 9 per cent. of which = 11 horse-power. With a propeller efficiency of 70 per cent., this gives an available horse-power for increase in rate of climb of 7·7 horse-power. Since the weight is 1,988, the increase in rate of climb should be $\frac{33{,}000 \times 7{\cdot}7}{1{,}988}$ = about 130, which agrees with that found.

The complete results in these two cases are shown in

Figs. 4 and 5. The consistent rate of climb of the D.H.4, in spite of the considerable difference in temperature between the two days, is very marked. The S.E.5 tests were carried out at Farnborough, and are the only performance tests I have ever seen which appear definitely to support the pressure theory. But there are inconsistencies about these tests which will be considered later. The observed differences between the propeller revolutions on the two days do not tally with the observed increase in rate of climb.

11. Figs. 6, 7 and 8 show further examples of performance tests taken at Martlesham Heath. These examples are not in any sense "selected." They comprise all examples which could be found of performances taken on consecutive days of considerably different temperatures. Fig. 6 shows performance of a Rolls-Royce D.H.9a. The observed rates of climb on the two days are again remarkably consistent. The temperature difference at 10,000 is 11 deg., and the observed difference in rate of climb on the pressure theory should have been about 60 ft. a minute. Fig. 7 refers to a Hispano Suiza S.E.5a. Here there is a distinct, though slight, increase in performance on the warmer day above 6,000 ft. At 14,000 ft. the difference in temperature is 10 deg. C. The difference in rate of climb should have been about 80 ft. a minute on the pressure theory, while the actual observations show a difference of nearly 40 ft. The rate of climb below 6,000 ft. is actually considerably greater on the colder day, but probably this is to be attributed largely to air currents, which may interfere considerably with the accuracy of performance tests at low heights. The last case, Fig. 8, gives results obtained with a Sopwith "Snipe" fitted with an air-cooled B.R.2 engine. Here there is a considerable difference in rate of climb at about 10,000 ft., but below 7,000 ft., where the temperature differences are even greater, the rates of climb on the two days are identical. Only in the case of S.E.5's do tests on days of different temperatures show differences in performances at all comparable with those expected in the "pressure" theory, and this is probably connected with the fact that the intake is placed just behind the radiator, so that the air entering the carburettor is artificially warmed. In all other cases examined, the evidence from performance tests is more favourable to the "density theory."

12. Further information on the variation of engine power with height can be obtained by investigating the change of propeller revolutions during flight under various conditions. This method of attack has been adopted at the R.A.E.

It has already been shown that on the density theory there should be no change in revolutions from day to day at the same standard height and airspeed, while on the pressure theory the change should be 1 per cent. for every 2·3 per cent. change in absolute temperature.

In the tables below, the observed and calculated variations are shown for all the performance tests already analysed above :—

Table VII.—*B.H.P. D.H.4 B/7910*

Standard Height.	Warm Day.			Cold Day.			Change in R.P.M.	
	Airspeed.	R.P.M.	Temperature.	Airspeed.	R.P.M.	Temperature.	Observed.	Calculated on Pressure Theory.
2,000	73	1,300	+13·0	74	1,290	6·0	−10	−15
4,000	72	1,290	+10·5	73	1,290	3·5	0	−15
8,000	70	1,300	+ 9·0	69	1,280	− 8·5	−20	−40
10,000	69	1,290	+ 8·0	67	1,280	−10·5	−10	−40
13,000	65	1,255	± 0·0	64	1,270	−15·5	+15	−30

Table VIII.—200 *Hispano S.E.5a* (*R.A.E. Tests*).

Standard Height.	Warm Day.			Cold Day.			Change in R.P.M.	
	Airspeed.	R.P.M.	Temperature.	Airspeed.	R.P.M.	Temperature.	Observed.	Calculated on Pressure Theory.
			deg. C.			deg. C.		
3,000	65	1,700	7·0	65	1,700	4·0	0	−10
5,000	65	1,700	5·5	65	1,700	0·0	0	−15
7,000	65	1,700	1·5	65	1,700	− 5·5	0	−20
9,000	62	1,660	− 1·0	65	1,685	−10·0	+ 5*	−25
11,000	62	1,660	− 3·0	62	1,650	−16·0	−10	−35
13,000	62	1,650	− 5·0	62	1,630	−20·0	−20	−40
15,000	62	1,650	− 7·0	62	1,625	−25·0	−25	−50

Table IX.—*D.H.9a. B/7664.*

Standard Height.	Warm Day.			Cold Day.			Change in. R.P.M.	
	Airspeed.	R.P.M.	Temperature.	Airspeed.	R.P.M.	Temperature.	Observed.	Calculated on Pressure Theory.
			deg. C.			deg. C.		
2,000	76	1,615	−10	76	1,605	− 7	−10	−10
6,000	73	1,615	2	72	1,595	− 2	−15*	−10
10,000	65	1,585	0	64	1,565	−11	−15*	−30
14,000	54	1,525	− 6	55	1,515	−17	−15*	−30

* Allowance has been made for a small difference in climbing airspeeds.

Table X.—"*Snipe*," *E/8006.*

Standard Height.	Warm Day.			Cold Day.			Change in R.P.M.	
	Airspeed.	R.P.M.	Temperature.	Airspeed.	R.P.M.	Temperature.	Observed.	Calculated on Pressure Theory.
			deg. C.			deg. C.		
5,000	68	1,260	+21·0	68	1,250	+10	−10	−20
10,000	67	1,230	+10·0	65	1,210	+ 1	−10*	−20
15,000	61	1,190	− 2·5	61	1,180	− 6	−10	− 5

* Allowance has been made for a small difference in climbing airspeeds.

It is clear from these figures that the differences in observed revolutions per minute from day to day are small and, on the whole, rather less than half the differences calculated on the pressure theory. But to make certain of such differences great accuracy is required.

13. This method of finding the law of variation of engine power with height has been extended by Mr. Pinsent and Mr. Renwick at the R.A.E. by investigating the change of propeller revolutions with pressure and temperature at various airspeeds and with the following engines :—

200 R.A.F. 4d (air-cooled, aluminium cylinders).
250 Rolls-Royce (water-cooled).
170 high-compression Hispano Suiza.
150 Hispano Suiza.
100 R.A.F. 1a (air-cooled).

The method of reducing the observations was to find a law of variation of power with height and temperature by trial and error, and from it to deduce a relation between $\frac{\text{Torque}}{\sigma N^2}$ and the advance per revolution, with which all the experimental observations should agree. It is claimed that the results show that the law—

"Horse-power varies as pressure"

is very closely true, while the density law is very inaccurate. I do not think the evidence can be regarded in any way as conclusive. The extreme variation in temperature at any one barometric height only exceeded 12 deg. in very few instances. Now, the whole difference between the two laws is covered by a difference in revolutions per minute of about 2 per cent. for this difference in temperature. If the difference is appreciably greater than this for 12 deg. C., then its cause must be sought in other influences than those of pressure and temperature. Small experimental errors are of great importance in such a case, and it would certainly be difficult to rely on direct observations of revolutions by the ordinary revolution indicator to within 1 per cent. At the time the experiments were carried out the effect of a possible temperature effect on the revolution indicator had not been examined. Subsequently it was found that although in the majority of instruments of the chronometric or governor type this error was likely to be very small, it might become considerable when using instruments of the electric or magnetic type. It should obviously be taken carefully into account in experiments which depend mainly on a high accuracy of observing revolutions.

Further, the assumption was made throughout that if the density was the determining factor, the brake horse-power must vary as some power of the density. This assumption is quite unwarranted, although without the actual figures it is difficult to estimate its effect on the results. The variation of brake horse-power with height, estimated by assuming the indicated horse-power to be proportional to the density, and allowing for the mechanical losses, gives a law which cannot be expressed as a power of the density, as may be easily seen by examining the figures given in the fourth column of Table VI.

Finally, when analysing the effect of the pressure on the revolutions, the possible propeller distortion has not been sufficiently considered. No definite data yet exist on this point, but it seems clear that it would require very little distortion to effect a change in propeller revolutions of 1 per cent. I do not wish to lay too much stress on criticisms, the effect of which cannot yet be supported by definite experimental evidence; they are put forward with the object of pointing out that conclusions depending on such small differences in revolutions cannot be entirely accepted unless supported by other evidence obtained from full-scale experiments. In their enthusiasm to dispose of the density theory, the supporters of the pressure theory seem to me to have gone to the opposite extreme and to be accepting a law which may in practice lead to equal if not greater errors, especially at great heights.

14. It is evident that owing to the difficulty of being certain that the ground horse-power of an engine is constant over considerable length of time, objections may be raised to all experiments which depend on observed changes in performance, and propeller revolutions, of aeroplanes on different days. The best way to decide the question would be to devise a method by which the relative horse-power at different heights could be measured accurately on the same day. The evolution of a satisfactory torque meter would solve the problem, but attempts in this direction have not yet been successful. Another method would be that of measuring the actual mass of air taken in by the engine at different revolutions and atmospheric conditions. Here also experiments have not yet been successful A venturimeter has been employed at the R.A.E. for the purpose, but erratic readings have been obtained, which were attributed to unsteady flow in the intake pipe. The hot-wire anemometer promises to be a satisfactory instrument, but so far as I know has not yet been adapted for the purpose. On the other hand, we have a good many records of the depression in the choke tube of a carburettor during flight. When the velocity of air through the choke is high, as it is in this case, the depression is very closely—

$$= k \rho V^2,$$

where k is a constant, ρ is the density in the choke, and V the velocity. For simplicity, the assumption will be made first that at constant r.p.m. the density in the choke is proportional to the atmospheric density. The error introduced in this way is not large, and will be taken into account later. Suppose measurements are taken at constant revolutions and different heights, then, if the indicated horse-power is proportional to the mass of air entering the cylinders, it is measured by—

$$\rho \times V = k \sqrt{\rho \times \text{Depression}}.$$

If indicated horse-power is proportional to the density, then V is constant and $\sqrt{\rho \times \text{depression}}$ is proportional to ρ,

or $\frac{\text{Depression}}{\text{Density}}$ is constant, and independent of height.

If, on the other hand, indicated horse-power is proportional to the external pressure, then—

$$\sqrt{\rho \times \text{Depression}} = k p.$$
$$= k^1 \rho \times T,$$

or $\frac{\text{Depression}}{\rho \times T^2} = \text{constant}$ (independent of height).

where T is the absolute temperature.

Now, on the average we get something like a 10 per cent. fall in absolute temperature between the ground and 15,000 ft. Hence, if the indicated horse-power were proportional to the pressure, the value of the expression $\frac{\text{depression}}{\text{density}}$ should be 20 per cent. higher at 15,000 ft. than near the ground. Experimental errors are small compared to this, so that such experiments should give a real criterion of the effect of height. Early measurements, taken both at the R.A.E. and at Martlesham Heath of choke tube depressions show in point of fact that the depression at constant revolutions per minute is very closely proportional to the external density. Some of the results obtained at the R.A.E. on a R.A.F. 1a B.E. 2 C. are given in a report by Mr. Elliott to the Advisory Committee in June, 1917. Recently some further careful experiments at Martlesham Heath have completely confirmed the early results. I will quote two sets of measurements obtained on a B.H.P. D.H.9 machine :—

The depression tube was a small pipe let in flush with the inner surface of the choke tube of a Zenith carburettor at its narrowest diameter, its opening being therefore a few millimetres below the top of the jet. The tube was connected to a diaphragm manometer constructed at the R.A.E. reading in centimetres of water, and the other side of the diaphragm was connected to the static tube of the airspeed indicator. The manometer records gave, therefore, the true differences of pressure between the choke tube and the external atmosphere. It was carefully calibrated and found to have a negligible temperature correction. Preliminary experiments with the engine on the bench showed that steady readings were obtained. The square root of the observed depression was approximately proportional to the brake horse power, which would be expected as the latter can be taken itself nearly proportional to the indicated horse-power.

Table XI.

R.P.M.	B.H.P.	Observed Choke Tube Depression (Cons. Water).	$\sqrt{D}$.	$\frac{\sqrt{D}}{\text{B.H.P.}}$
1,100	197	66	8·1	0·041
1,200	217	74	8·6	0·0395
1,300	238	94	9·7	0·041
1,400	257	112	10·6	0·041
1,500	272	121	11·0	0·040

By taking into account the difference in density between the choke tube and the external air, the expressions given above become—

$\frac{D \times \sigma'}{\sigma^2}$ should be constant if indicated horse-power $\propto$ density.

$\frac{D \times \sigma'}{\sigma^2 T^2}$ should be constant if indicated horse-power $\propto$ pressure.

Where D is the depression and σ' the relative density in the choke.

A typical set of observations is given in Table XII on the next page.

The pressure in the choke tube is the difference between columns 4 and 6. To obtain the density σ' the assumption has been made that the air temperature at the choke is the same as the external temperature; it comes to the same thing if we assume that the difference in temperature, if any, between the choke tube and the external temperature is proportional to the absolute temperature. In the particular engine under consideration the intakes open out to the external atmosphere, and there is no heating to a point above the

TABLE XII.—(REVOLUTIONS PER MINUTE = 1,200.)

(1) Aneroid Height.	(2) Pressure, Inches Hg.	(3) Temperature	(4) Relative Density.	(5) Choke Tube Depression = D.	(6) Pressure in Choke Tube.	(7) Density Choke Tube = σ'	(8) $\frac{D \times \sigma'}{\sigma^2}$	(9) $\frac{D \times \sigma'}{\sigma^2 T^2 \times 10^5}$
				cm. water.	in. Hg.			
2,000	27·7	9·5	0·95	83·0	25·3	0·865	80	1·00
4,000	25·8	5·0	0·90	76·0	23·6	0·82	77	1·00
6,000	24·0	1·5	0·845	72·0	21·9	0·775	78	1·05
8,000	22·0	− 3·0	0·80	69·0	20·2	0·72	78	1·07
10,000	20·7	− 5·0	0·75	65·0	18·8	0·68	79	1·10
12,000	19·3	− 8·0	0·70	61·0	17·5	0·64	80	1·14
14,000	17·9	−11·0	0·66	57·0	16·2	0·60	79	1·15
17,000	16·0	−17·0	0·60	52·5	14·5	0·55	80	1·22
20,000	14·3	−21·5	0·55	49·0	12·9	0·50	80	1·26

carburettor. Further, as already said, the depression is taken at a point below the top of the jet, so that there is no appreciable cooling at this point due to the evaporation of petrol. The assumption is therefore very reasonable, and the error introduced must be very small. The constancy of the product $\frac{D \times \sigma'}{\sigma^2}$ given in column 8 is remarkable. It is certainly within the errors of observation. On the other hand, the column 9 gives values of $\frac{D \times \sigma'}{\sigma^2 T^2}$, which should be constant if the indicated horse-power is proportional to the pressure only. Actually these values steadily increase, the value at a density of ·55 (about 10,000 standard feet) being 26 per cent. higher than the value at 2,000 ft. This at least gives strong support to the view that the indicated horse-power follows the density law more closely than the pressure law.

Very similar results were obtained with the Hispano S.E.5, although in this case the mouth of the intake was just behind the radiator. In view of these results it certainly seems most desirable to make further attempts to measure directly the mass of air entering the cylinders. The fact that steady readings are obtained with one depression tube in the choke tube of a carburettor feeding only three cylinders would lead one to suppose that with proper precautions the venturi method of direct measurement could be made to work. A good deal depends on the surface of the depression tube being absolutely flush with the inner surface of the tube. Certainly when carrying out flights to settle small differences between full-scale and model results *e.g.*, on wing sections or propellers, it appears essential to obtain a check on the observations by some such measurements. A small difference in engine horse-power may account for a large part of the observed differences in such cases, and everyone who has worked with internal combustion engines knows how much the power can vary with the working conditions, even when the external atmospheric conditions are constant. If an engine is opened up suddenly, either on the bench or in the air, a very high power can be obtained. Such "snatch" horse-power can be up to 10 or 15 per cent. higher than the average horse-power on a long run, but in all such cases it can be shown that the choke depression is correspondingly higher.

15. In conclusion, giving due weight to the various theoretical considerations and experimental results put forward, the following statements fairly represent our knowledge at the present time:—

(*a*) The effect of temperature on the power of a multi-cylinder engine (fitted with an ordinary carburettor) on the ground, under normal working conditions, is only about one-third to one-half of that calculated on the density theory.

(*b*) Evidence obtained both from bench tests under artificial altitude conditions, and from flight tests, show that neither the indicated nor the brake horse-power of an engine is even approximately proportional to the external pressure only, when both temperature and pressure are varied considerably—for example, within the limits corresponding to average conditions at ground level and 20,000 ft.

(*c*) At comparatively low heights (less than 10,000 ft.) the assumption that the brake horse-power is proportional to the pressure, gives approximately accurate results, but the errors introduced are about the same in magnitude as those introduced by assuming the "density theory," but opposite in sign. At greater heights and lower densities the evidence goes to show that the density theory is more accurate. The variation of the B.H.P. engine appears to follow the density law most closely, while that of the Hispano Suiza is the most divergent.

Considering all the available evidence, no good case can be made out at the present time for abandoning the standard method of reducing performances in favour of one which assumes that engine power is independent of atmospheric temperature. Such a change will certainly introduce equal, if not greater, errors.

When an exact estimate of the available horse-power in flight is required, it appears essential to measure it directly, and not to depend on the results of bench tests made often some time previously. In addition to what has already been remarked about this, it may be pointed out that the power measured on the bench cannot as a rule be guaranteed to within 2 per cent., and does not at all necessarily correspond to the power at the same revolutions per minute near the ground in flight, since both the shape of air intakes and of exhaust pipes and their position in the slip stream may have an effect comparable to, if not greater than, the error introduced by calculating the horse-power at greater heights according to the theories discussed in this paper.

CATALOGUES.

Steel Structures is the title of a quarterly journal issued by the British Engineering Association on behalf of about 25 British firms interested in steel frame buildings. A number of erections are illustrated in skeleton form and described in the text.

Electric Cranes.—Four types of electric overhead travelling cranes are illustrated on a broad sheet issued by Messrs. S. H. Heywood and Co., Limited, Reddish, near Stockport. These are suitable for foundries, workshops, warehouses, car-repairing sheds, &c. The largest has a span of 70 ft. and carries a load of 5 tons; another, of over 43 ft. span, carries a load of 15 tons. The designs make for easy and rapid working.

Steam Pipe Covering.—It is well known that effective heat-retaining covering for steam pipes has advantages even apart from an appreciable saving in weight of fuel used in the boiler. The high price of coal may lead to the clothing of a larger number of pipes. Messrs. Turner Brothers Asbestos Company, Limited, Rochdale, who are specialists in this work, issue a "propaganda" kind of catalogue on this subject and offer technical advice to those who apply for it.

Theodolite.—An instrument specially adapted for use in mines is shown in a catalogue from Messrs. T. Cook and Sons, Limited, York, and 3, Broadway, S.W. 1; it is made dust-proof, with machine-ground bubbles, and designed for convenient adjustment and reading in mining conditions. All cast parts are of gun-metal. This firm also send a catalogue of an irrigation level which is specially made for use by farmers and is very strongly and conveniently designed, only 11 lb. weight complete, and at a most reasonable price.

Aluminium.—The British Aluminium Company, Limited, 109, Queen Victoria-street, E.C. 4, has issued a useful catalogue giving a list of nearly 80 thicknesses of sheet, from 0·375 in. to 0·008 in., both standard wire gauge and Birmingham sheet gauge being provided for. The table gives the thickness in gauge numbers, inches and millimetres; also the weights in pounds per square foot with the weights of brass, copper and steel sheet for comparison. Other technical data, practical hints on working and illustrations of special section rods for motor-car and aircraft work, make the catalogue of value for reference purposes.

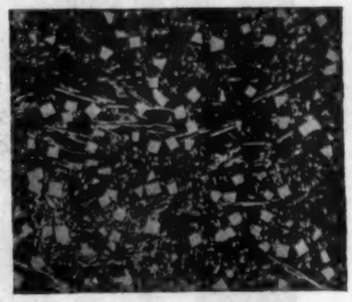
Machine Tools.—The catalogue of the Associated British Machine Tool Makers, Limited, is a strongly-bound quarto volume of over 600 pages, closely filled with illustrations, specifications and terse descriptive matter. Practically all engineers' machine tools, including lathes in various forms and machines for drilling, planing, slotting, shaping, milling, screwing, broaching, grinding, gear cutting, profiling, cutting-off, &c., are shown in a most plentiful variety of size and special adaptation: for example, about 20 types of lathe, each in a variety of sizes. Turning tools, grinding wheels, milling cutters, chucks, steadies, and all cutting and fixing accessories for the machines are also included. The associated firms are: J. Archdale and Co., Limited, Birmingham; W. Asquith, Limited, Halifax; J. Butler and Co., Halifax; Churchill Machine Tool Company, Limited, Manchester; Kendall and Gent, Limited, Manchester; J. Lang and Sons, Limited, Johnstone; J. Parkinson and Son, Shipley; G. Richards and Co., Limited, Broadheath; T. Shanks and Co., Johnstone; Smith and Coventry, Limited, Manchester; H. W. Ward and Co., Limited, Birmingham. The principle on which the association is founded leaves the capital and management of each firm independent and establishes a joint organisation for selling, furnishing expert advice, and investigating foreign markets. Each firm concentrates on certain types of machine, developing and improving both machine and methods of exact and economical production in quantities, instead of spreading its energies over too great a range of production. It would be impossible to give any fair summary of the contents of this catalogue beyond the list of types already mentioned; and it would be premature to examine it closely with a view to stating how far the associated firms will be able to set up a severe competition with the few kinds of machines imported in large numbers. The main test of the usefulness of the co-operative form of joint working will be shown in its power of promoting sales in foreign markets on safe business lines. It can only be said at present that it seems well equipped for that very difficult task.

OBSERVATIONS ON A TYPICAL BEARING METAL.*

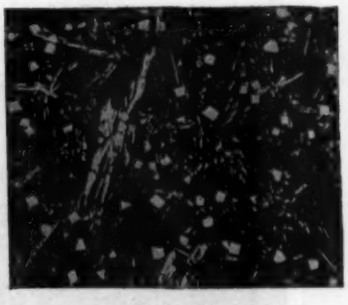
By HILDA E. FEY and W. ROSENHAIN, D.Sc., F.R.S., Vice-President (from the National Physical Laboratory).

THE metallographic and physical study of bearing metals (white metals) does not appear to have received the attention it deserves. At all events, the literature on the subject is very scanty. The attention of the authors was called to this matter when the problem of arriving at a standard specification for aircraft bearing metals came before a Sub-committee of the British Engineering Standards Association, of which one of them is a member.

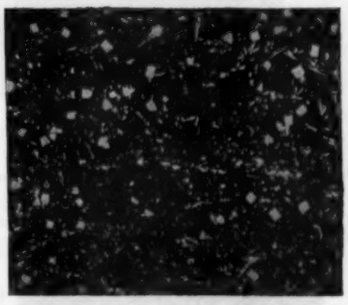
Consideration of the subject showed that, quite apart from the composition of the bearing metal, its micro-structure, and, consequently, its physical properties, must vary widely with the circumstances in which the bearing is prepared. The liquid-bearing metal is run into position under widely varying circumstances in different classes of machinery, so that the rate of solidification must be very different in different cases. In order to study, in a preliminary manner, the effect of such varying conditions on a bearing metal, experiments have been made on a single alloy of typical composition, containing approximately 4 per cent. copper, 9 per cent. antimony and 87 per cent. tin, and specimens of this alloy have been prepared by casting from various temperatures into small ingot moulds of different kinds. The resulting ingots have been thoroughly examined microscopically, and measurements of Brinell hardness have been made. It is, of course, recognised that Brinell hardness is not necessarily even an approximate measure of the value of a bearing metal, but it has been used because it is the only method of physical testing which is readily applicable to a large number of small ingots, and because it serves as a general guide to the variation of physical properties accompanying different



No. 1. Top of ingot 1 (*a*). Cast in warm sand



No. 2. Middle of ingot 1 (*a*).



No. 3. Bottom of ingot 1 (*a*).

FIGS. 1 TO 3. MAGNIFICATION × 50.

* Paper read before the Institute of Metals, September 25, 1919.

casting conditions and the corresponding variations of microstructure.

The chemical composition of the alloy aimed at was already stated, viz., 4 per cent. copper, 9 per cent. antimony and 87 per cent. tin. Chemical analysis of the actual alloy used in the experiments gave the following figures :—

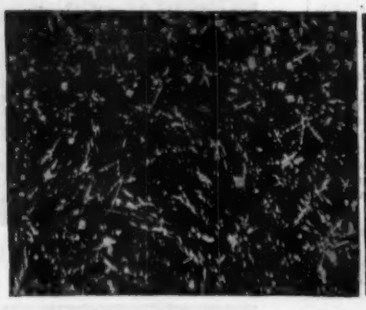
	Per cent.
Copper	4·4
Antimony	8·76
Tin	86·84

against a yellowish background composed mainly of tin. Etching with a 1 per cent. solution of hydrochloric acid in alcohol darkens the ground-mass and so renders the whole structure more distinct. It is found that with a light etch the ground-mass shows light and dark patches, due to coring, especially in the alloys with coarse structure, where the dark patches are very well marked, forming a rough pattern beneath the chains of the copper-tin constituent. This feature disappears on annealing either at 100 deg. C. or at 200 deg. C.

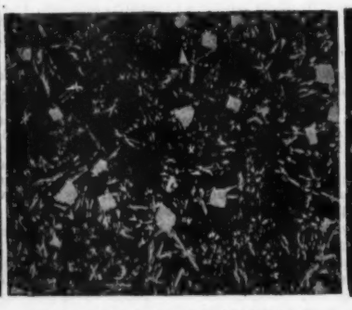
Sand Casting 1*a*, 1*b*, 1*c*, 3*a*, 3*b*, 3*c*, 2*c*1, 2*c*2.—The crystals at the bottom of the ingot, and a corresponding increase at the top, showing that the crystals have a lower specific gravity than the liquid tin-rich matrix in which they are formed, and tend to rise to the top if time is allowed before solidification. This is illustrated in Nos. 1, 2 and 3, representing photomicrographs of the top, centre and bottom respectively of ingot 1*a*, under a magnification of 50 diameters. This ingot was cast at 300 deg. C., which was regarded as the lowest temperature at which pouring could be carried out. As this temperature is just below the liquidus of the

No. 4. Ingot 1 (*b*). Cast from high temperature in warm sand. × 50.

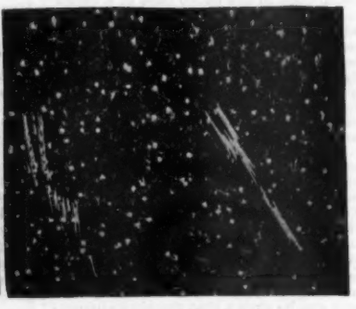
No. 5. Ingot 1 (*c*). Cast from medium temperature in warm sand. × 50.



No. 6. Ingot 2 (*c*) 1. Chilled side.

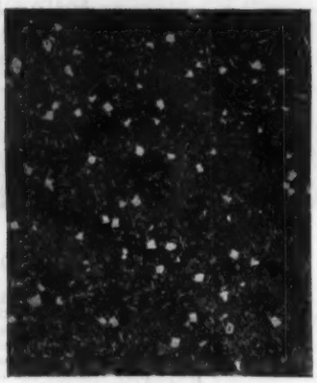


No. 7. Ingot 2 (*c*) 2. Sand side.

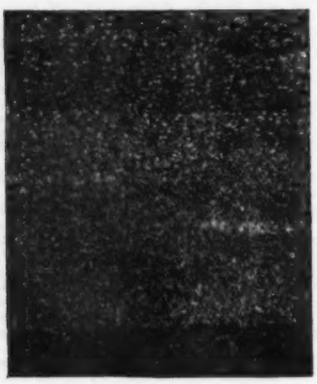


No. 8. Ingot 4 (*a*). Cold chill.

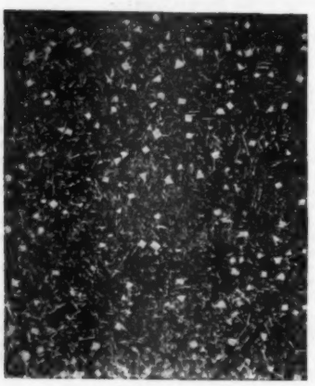
Figs. 4 to 8. Magnification × 50.



No. 9. Ingot 4 (*c*). Cast into "Chill" at 100° C. × 50.



No. 10. Ingot 4 (*c*). Chilled edge. × 20.



No. 11. Ingot 7. Cast into "Chill" mould at 200° C. × 50.

The size of ingot adopted measures 3 in. high by ½ in. square, and both sand moulds and chill moulds, machined out of blocks of steel, have been used. Ingots have been cast in these moulds, using casting temperatures varying from relatively high to medium and very low temperatures.

Microscopic Examination.—The ingots were cut down the middle and the whole surface polished, so as to determine whether there was any variation in structure from top to bottom, or from side to side, of the casting. The polished sections, before etching, show the cuboids of the antimony-tin compound, and the long needle-like crystals of the copper-tin constituent, white and shining, metal was poured, in the case of ingots marked (*a*), at 300 deg. C., in those marked (*b*) at 600 deg. C., and in those marked (*c*) at 400 deg. C., into warm and cold sand moulds 3 in. by ½ in. by ½ in. in size. The warm moulds were heated to a temperature of about 60 deg. C., but small differences in the temperature of the mould are not accompanied by any striking difference in structure, the crystal size being approximately the same for the same temperature of pouring, with the slight difference that the arrangement of the copper-tin needles is less regular in the ingots cast into cold sand than in those cast into warm sand moulds. In each case there is a marked diminution in the number of relatively large alloy it is too low to produce a uniform structure, since the liquid already contains large crystals of one of the constituents. The high-temperature casting, 1*b*, produces a very coarse crystallisation, with cuboids reaching 0·09 mm. in diameter. This is illustrated in No. 4. Where the temperature of casting was 400 deg. C. (No. 5) the cuboids are still large, being about 0·07 mm in diameter, but the copper-tin constituent has not formed the network characteristic of very slow cooling.

Castings were also made in warm and cold sand moulds having one chill face, the metal being poured at 400 deg. C. A very coarse structure resulted from the use of a warm sand mould, but in both cases there was a fine-

grained border along the chilled edge, where the cuboids were either very small or entirely absent. Figs. 6 and 7 show the difference in size of the crystals on the chill side and sand side respectively of the cold mould.

Chill Castings 4a, 4c, 5a, 6a, 6c, 7.—In the chill castings there was considerably less difference between the ingots poured at 300 deg. C. and those poured at 400 deg. C. than in the sand castings. The structure was fine-grained in both cases, but, as before, it was more uniform when pouring took place at 400 deg. C. than at 300 deg. C. (see Nos. 8 and 9). The tendency for the cuboid crystals to become concentrated towards the top of the ingots, as seen in the more slowly-cooled sand castings, is absent in the chill castings, which are practically uniform from top to bottom. If the mould is cold or warmed only to 100 deg. C., there is, however, a very definite chilled border on either side of the ingot, as illustrated in No. 10, and raising the temperature of pouring from 300 deg. C. to 400 deg. C. increases the width of the border. When, however, the temperature of the mould is raised to 200 deg. C. and the metal poured at 350 deg. C., the structure is uniform and fine-grained throughout, becoming somewhat finer at the extreme edges of the ingot, but showing no truly chilled edge (Nos. 11 and 12).

The depth of chill in the chill cast ingots is as follows :—

TABLE I.

Ingot.	Temperature of Casting.	Temperature of Mould.	Depth of Chill.
	deg. C.	deg. C.	In.
4a	300	cold	0·08
4c	400	cold	0·10
5a	300	350	0·02
6a	300	100	0·06
6c	400	100	0·096
7	350	200	—

In the use of white metal bearings for marine purposes it is common practice to hammer-dress the cast bearings, for the purpose, no doubt, of closing up any cavities and generally improving the soundness of the metal.

In order to ascertain what the probable effects of this form of treatment on a bearing metal are likely to be, some experiments in hammering various ingots of the present series have been carried out. For this purpose typical ingots, having widely varying structures, have been used, and the amount of hammering to which they

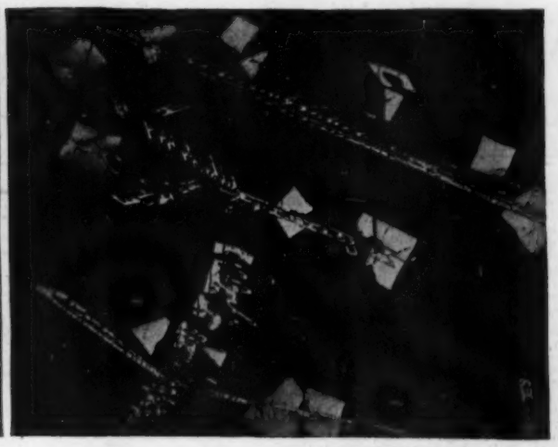
No. 12. Ingot 7. Edge. × 20.

ingot 1b), hammering followed by annealing at 100 deg. C. results in appreciable softening. It is interesting to note that the fine-grained ingots stood the hammering comparatively well; ingot No. 7 in particular was easily reduced by 58 per cent. The coarsely crystalline ingots 1b and 5a cracked and broke after a small amount of hammering.

Microscopic examination of the specimens which had been subjected to hammering showed that both the cuboid and the copper-tin crystals had been, to a certain extent, crushed and broken by this treatment. This did not produce much apparent alteration in the structure of the ingots 4a, 4c, 6a and 7, where the crystals were already small and were evenly scattered in the matrix, though the uneven edges and irregular shapes of the broken cuboids are easily seen under a high magnification. In the coarsely crystalline samples the results of hammering are much more evident, as is shown by a comparison of Nos. 13 and 14. No. 13 represents ingot 5a, which was poured into a mould at a temperature higher than that of the metal itself, and therefore very slowly cooled. No. 14 shows the same ingot after hammering, and it would seem that the hard copper-tin needles have been hammered on to the cuboids and have cracked them, and also that the needles themselves are broken successively at right angles to their long axes. Where the cuboids are not in contact with the copper-tin needles they appear much less damaged.

The observations which have been described in this paper obviously constitute no more than the beginning of a serious metallographic study of white-bearing metals. They serve to show, however, that much can be learnt from such a study, and particularly that the method of casting and treating these alloys must profoundly affect their behaviour, since it affects their microstructure in such a marked manner. The remarkable results of hardness measurements on hammered specimens indicate that these alloys behave in a way which, by comparison with other alloys, must be regarded as anomalous. The practical question whether a bearing

No 13. Ingot 5 (*a*). Cast into steel mould at 350° C. × 50.



No. 14. Ingot 5 (*a*). After hammering and annealing. × 50.

Brinell Hardness Measurements.—These have been made, using a 5 mm. ball and a load of 125 kg. The small ball was adopted, because impressions made with a 10 mm. ball proved to have irregular outlines and were difficult to measure. The results of the Brinell measurements are stated in the following table :—

TABLE II.—*Brinell Hardness.*

Ingot.	Temperature of Casting.	Type of Mould.	Brinell Number.		
			Top	Middle.	Bottom.
	deg. C.				
1a	300	Warm sand	25·2	—	25·6
1b	600	Warm sand	26·7	—	26·9
1c	400	Warm sand	25·6	—	26·0
2a	300	Cold sand	26·7	27·7	29·2
2b	600	Cold sand	29·8*	30·0	30·0
2c	400	Cold sand	28·3	26·9	28·1
4a	300	Cold metal	30·0	30·0	29·8
4c	400	Cold metal	32·1	31·9	32·3
5a	300	Met. mould at 350 deg. C.	29·6	28·2	28·2
6a	300	Met. mould at 100 deg. C.	28·5	29·6	32·7
6c	400	Met. mould at100 deg. C.	32·1	31·2	32·3
7	350	Met. mould at 200 deg. C.	30·0	29·0	30·6

* Porous at top.

It will be seen from the above table that the variations of Brinell number are relatively small, the lowest value being 25·2 and the highest 32·7. On the whole, however, the hardness numbers show that the chill cast specimens are generally harder than those cast in sand; but in some cases there is considerable variation in different parts of the same ingot, due, probably, to chilling at the ends.

have been subjected, together with the resulting Brinell hardness numbers, both before hammering, immediately after hammering, and after annealing or ageing at 100 deg. C., are given in Table III :—

TABLE III.

Ingot.	Reduction.	Brinell Hardness Number.			
		Before Hammering.	Immediately after Hammering.	½ hour Annealing after Hammering.	16 Hours Annealing after Hammering.
1b	17per cent. (Broke on hammering)	26·9	27·3	25·0	22·3
4a	20 per cent.	30·0	28·5	27·1	27·7
4c	17 per cent.	31·9	28·7	29·4	26·0
5a	18 per cent. (Cracked on hammering)	28·2	26·0	23·0	23·7
6a	17 per cent.	29·6	25·2	26·2	24·2
7	58 per cent.	30·0	27·7	25·0	24·0

Six ingots in all have been hammered and tested for hardness, the test being made on the hammered face within ten minutes of that operation and after only a very little of the surface had been removed by grinding. The ingots were then kept for half an hour at 100 deg. C. and re-tested. They were again heated to 100 deg. C. and maintained at that temperature for 16 hours and again tested.

The resulting figures are given above, and show the remarkable result that, while hammering alone, so far from hardening this alloy, actually brings the hardness number down to a small extent (except in the case of

is injured or improved by hammering is left open, although it is difficult to believe that treatment which shatters the harder crystals can be advantageous.

The authors are obliged to Sir Richard T. Glazebrook, C.B., F.R.S., Director of the Laboratory, for permission to publish this paper.

HIGHER COAL PRICES IN GERMANY.—The Ruhr coal mine owners have applied for permission to raise the price of coal from 45 marks to 57 and 60 marks per ton, but the authorities naturally do not favour such a material increase. The new German system for regulating the coal supply has not yet come into operation, or at least only partly so, the Imperial Coal Union (Reichskohlenbund) having only been due to commence operations on October 1, and the Imperial Coal Council (Reichskohlenrat) was only to start work about the middle of October. It looks as if the mine owners had intentionally asked for such a high increase, so that they may be able to bargain with the authorities. The decision may be delayed for some weeks, as the authorities wish first to consult the workers.

FOREIGN COMPETITION IN NEW ZEALAND.—During the three years 1914–17, the United States of America doubled the volume of their business with New Zealand, while Japan's trade accomplished a fourfold increase over its pre-war amount. The freight rate for Japanese goods from Tokio to New Zealand is now 22*s.* 6*d.*, while that from London to New Zealand is 110*s.* per ton. These facts are disturbing, and, considered in conjunction with England's present manufacturing difficulties, go to emphasise further the necessity for the closest co-operation and sympathy with every overseas organisation aiming at the extension of British trade. In this connection, the Federation of British Industries, which has made this statement, call attention to the New Zealand Association of British Manufacturers and Agents.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Name, &c., of the Communicators are give in italics.

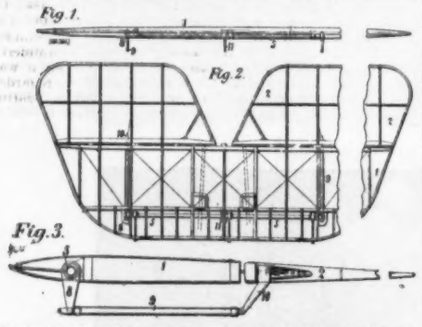
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 6d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any grounds mentioned in the Act.

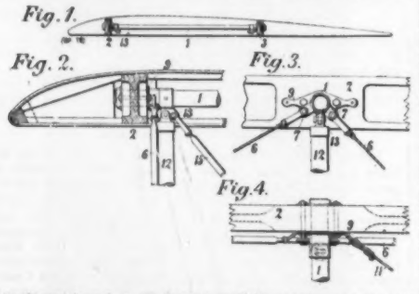
AERONAUTICS.

130,355. William Beardmore and Co., Limited, Dalmuir, and G. T. Richards, London. Aeroplane Flying Machines. (3 *Figs.*) January 25, 1918.—The objects of this invention are to provide improved means for controlling and actuating the rearwardly located elevators of aeroplane flying machines. According to this invention, a rock shaft 5 is carried in bearings at the forward part of the tail plane 1 and extends transversely across and for a proper distance beyond the sides of the fuselage, and an operating arm 11 is fixed about centrally on the rock shaft and extends within the fuselage, the said operating arm being connected with opposite ends of the control cables guided within



the fuselage by which the aviator can suitably rock the rock shaft, and mechanical connections are provided between the ends of the rock shaft which project beyond the sides of the fuselage and the respective elevators, so that the elevators shall be rocked about their hinges in concordance with the angular adjustments given to the rock shaft. A convenient form of such mechanical connections between the rock shaft 5 and the elevators 2 consists in fixing an arm 8 on each end of the rock shaft and an arm on to each elevator 10 and providing connecting rods 9 connecting the arms of the elevators with the corresponding arms of the rock shaft. (*Accepted August* 13, 1919.)

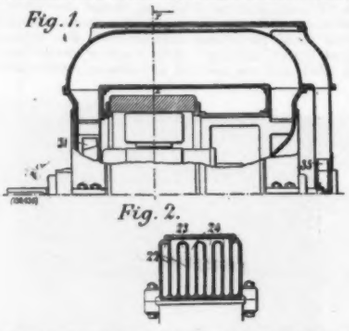
130,428. Boulton and Paul, Limited, Norwich, and J. D. North, Burgh Apton. Aeroplane Flying Machines. (4 *Figs.*) February 22, 1918.—This invention particularly relates to the wing structure of aeroplane flying machines. According to this invention, a cross-member 1 is provided, extending in the longitudinal direction of the machine and fixed between the front and rear wing spars 2, 3, the said spars being, for example, bored near the neutral axis to receive the ends of the cross-member which may be passed through the wing spars and secured in a suitable manner. This cross-member 1, which is thus supported at its ends by the front and rear wing spars 2, 3, has fixed to it



attachment lugs 9, 7, 13, formed on fittings embracing the said cross-member, and separate fittings may be used for the internal, bracing wires 11, for the external bracing wires 6 and for the interplane struts 12, and the incidence wires 15, and one or more of such fittings is rigidly fixed to the cross-member which is or may serve as a drift strut. Generally the attachment lugs are located on said cross members or drift struts adjacent to the wing spars 2, 3, and the fittings carrying the attachment lugs may be arranged on said cross-members or drift struts in such a manner as to induce greater or less bending stresses in that member. (*Accepted August* 13, 1919.)

ELECTRICAL APPARATUS.

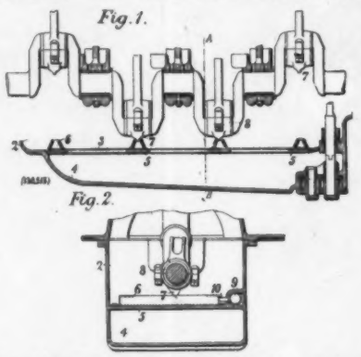
130,435. J. W. Burleigh, Burnham, Somerset. Dynamo-Electric Machinery. (6 *Figs.*) May 30, 1918.—This invention has reference to dynamo-electric machines, of the totally-enclosed type provided with means for circulating and cooling the air enclosed within the machine casing, said means being mounted externally of the machine casing and forming, in effect, a superstructure. The invention has for object to provide in heat interchanging means of the kind described, an improved construction of the device or part by or through which the exchange of heat is effected (therein called a heat interchanger). In accordance with this invention, a heat interchanger for use with heat interchanging means as herein referred to comprises a casing provided internally with longitudinal walls 22, the several walls constituting an integral body and forming a plurality of open-ended ducts 24 and a plurality of closed ducts 23, the closed and open-ended ducts alternating with one another and the closed



ducts being connected with the machine casing and constituting therewith a closed circuit through which the heated air is circulated by a fan 31 mounted on one end of the armature spindle, and the open-ended ducts being connected with the delivery end of a fan 35 or pump mounted on the other end of the armature spindle. (*Accepted August* 13, 1919.)

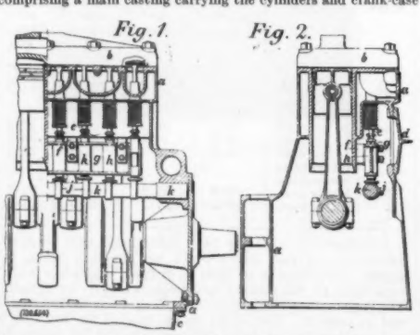
GAS ENGINES, PRODUCERS, HOLDERS, &c.

130,515. H. Smith, Coventry, and M. Wild, Coventry. Internal-Combustion Engines. (5 *Figs.*) October 17, 1918.—This invention comprises improvements in the lubrication of internal-combustion engines and refers to engines in which the splash system of lubrication is used. The lower part 2 of the crank-case is webbed internally as usual to carry the grid 3 which separates the crank chamber from the oil sump 4, and is also formed with transversely-disposed bridge pieces 5 to carry special oil troughs 6, which constitute the subject matter of the present invention. In the construction shown it will be seen, more particularly from Fig. 1, that the oil troughs are of approximately triangular cross-section having a relatively narrow slot at the apex through which the dipper 7 on the big end 8 of the connecting rod enters the trough. By this means only a very



small surface of oil is subject to the disturbing effects of air pressure or displacement as the result of the rotation of the crank and big ends. The troughs are fed as usual from a passage 9 cast in the side of the crank-case, by means of short tubes 10, said passage being common to all the troughs and communicating with the oil pump in the sump. The upper edge of the troughs may either be straight as shown in Fig. 2 or of arcuate form. This latter formation of the trough not only reduces the amount of oil displaced as waste, but also lengthens the period of immersion of the dipper by reason of the fact that the oil which is raised by the movement of the dipper above the normal level is retained in the raised portion of the trough instead of overflowing. This effect may be enhanced by roofing or covering in the end portions of the troughs. (*Accepted August* 13, 1919.)

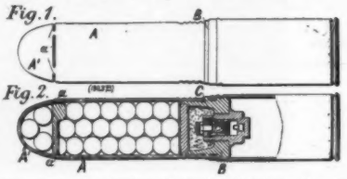
130,554. J. Tylor and Sons, Limited, London, and A. C. Butcher, North Finchley, London. Internal-Combustion Engines. (2 *Figs.*) February 12, 1919.—This invention relates to automobile engines which are constructed with a casing comprising a main casting carrying the cylinders and crank-case



in one piece, and adjacent to the cylinders, as an integral part thereof, the several guides for the valve mechanism which is enclosed within the casing. *a* is the main casting extending from the cylinder cover *b* down to the crank cover *c* that is bolted to, and forms the bottom of, the crank chamber which is an integral part of the casting *a*. Longitudinally disposed of this casting is the cover plate *d* that is removable for the purpose of gaining access to the valve gear *e*. The cylinders of the casting *a* are provided with projections *f*, to which is attached a separate casting *g*, that carries the guides *h* through which the valve tappet spindles *i* are reciprocated in a vertical direction by the cams *j*, on the wayshaft *k*, that is rotated at half the speed of the crankshaft in any well-known manner. Obviously the projections *f* can be readily machined so that a smooth or finished surface is provided between the casting *g* and the main casting *a*, the casting *g* being attached to the main casting *a* by means of studs and nuts as shown. On the removal of the cover plate *d* the casting or castings *g* may be disconnected together with those portions of the valve gear which are supported in the several guides *h*, any one of which can then be repaired or renewed if and when need be and reassembled without interfering with or dismantling any other parts of the engine. (*Accepted August* 13, 1919.)

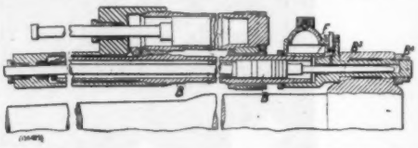
GUNS AND EXPLOSIVES.

130,373. Vickers, Limited, Westminster, London, and T. K. North, Westminster, London. Projectiles. (4 *Figs.*) February 4, 1918.—This invention relates to shrapnel shells of the kind composed of two main parts, viz., a light envelope or casing containing the projectiles and a base which carries the driving band and to which the envelope is attached. According to the invention, the shell comprises in combination with the base B and the light envelope A, an ignition device C carried by the base for exploding the expelling charge disposed in the base and a nose A^1 which is so formed or is so secured to the envelope A that the forward movement of the projectiles in the envelope as a result of the explosion of the charge in the base will cause



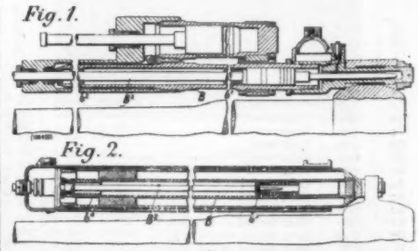
the nose to become broken off or detached from the envelope. The light envelope is preferably drawn from steel or other suitable metal or alloy and is formed with a thread which is preferably pressed or rolled into the rear part thereof and engages with a similarly-shaped thread on the base. The light envelope may be formed with circumferential slots or saw cuts *a* so that on the explosion of the charge in the base of the shell, the nose will be broken off and the bullets expelled forward relatively to the shell. Alternatively and with the same object in view, the nose may be made separate from the envelope (which in this case may be made of light steel tubing) and be lightly secured to the envelope by the rear part of the nose being spun or pressed into a circumferential groove in the envelope. (*Accepted August* 13, 1919.)

130,423. Sir A. T. Dawson, Westminster, London, and Sir G. T. Buckham, Westminster, London. Ordnance Recoil and Run-out Gear. (1 *Fig.*) January 19, 1917.—This invention relates to ordnance recoil and run-out gear of the hydro-pneumatic type having an air reservoir in communication with a cylinder serving the dual purpose of a recuperator cylinder and a recoil or brake cylinder and also having a cushioning device



for bringing the gun gently to rest at the termination of the run-out movement. According to the invention, there is provided a retarding ram B^3 and a recess B^4 which the ram enters as the gun returns to its run-out or firing position and to which, as there would otherwise be no liquid at the rear of the piston B^1, liquid is automatically admitted from a chamber F which is independent of the liquid in the aforesaid cylinder B. (*Accepted August* 13, 1919.)

130,422. Sir A. T. Dawson, Westminster, London, and Sir G. T. Buckham, Westminster, London. Ordnance Recoil and Run-out Gear. (2 *Figs.*) January 19, 1917.—This invention relates to ordnance recoil and run-out gear of the hydro-pneumatic type having an air reservoir communicating with a cylinder serving the dual purpose of a recuperator cylinder and a recoil or brake cylinder, and also having means for retarding the final portion of the recoil movement of the gun. According to the invention, the said retarding means comprise a device which is so constructed and arranged that as the gun is completing its recoil movement, it gradually closes the aperture in the aforesaid cylinder through which liquid passes from the cylinder



to the air reservoir during the recoil of the gun and also from the air reservoir to the cylinder during the run out of the gun. In one construction, the said device is in the form of a ram b^1 of tapered or other suitable formation which, towards the end of the recoil movement of the gun, enters part b^2 of the aforesaid cylinder B, which is of smaller diameter than the remainder of the cylinder; in another construction (Fig. 2) the said device is in the form of a spring controlled valve b^5 which is slidably mounted on the piston rod B^2 of the aforesaid cylinder and which, when the gun is approaching the end of its recoil movement, closes on a seating b^4 at the open end of the said cylinder. (*Accepted August* 13, 1919.)